International Best Practices in Critical Care

Editors

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Foreward

This critical care nursing textbook is written by nurses, for nurses. The authors are to be congratulated on an extensive and comprehensive body of work that covers a wide range of critical care topics. This text is significant in that it represents the first international collaboration of its kind, which was brokered by the World Federation of Critical Care Nurses, with the majority of its authors involved actively with the Federation. With contributions from leading nurses from fourteen different nations, it is a truly multi-national collaboration. It is also highly significant that the electronic version of this text has been made available for any nurse anywhere in the world to download free of charge.

The text is packed full with up-to-date information that is supported by an excellent evidence base of reference material. The content is both broad and detailed, and provides a useful resource for all critical care nurses, regardless of their area of practice. As well, it should be considered as a standard reference text for nurses that are studying critical care nursing.

I warmly congratulate the authors on this wonderful text and look forward to seeing further editions in the coming years!

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Table of Contents

Chapter 1

Critical Care Nursing's Role in Prevention of Harm: Going Back to the Basics with Evidence

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Learning Outcomes

After completing this e-chapter you will be able to:

1. Explain the Interventional Care Model as a framework in redesigning how we approach nurse sensitive care practices and patient outcomes

2. Describe how Sustaining Nursing Clinical Practice framework helps to ensure reintroduction and valuing of evidence basic nursing care in conjunction with the right resources and systems to sustain practice.

3. Identify various evidence-based strategies to reduce pressure, shear, friction and moisture injuries.

4. Describe the effect of healthcare-associated infections on mortality, morbidity, and cost of health care

5. Define key care practices based on the evidence that can reduce bacterial load and/or prevent the development of health care acquired infections.
6. Describe ICU acquired weakness and delirium and the impact on short and long term outcomes for critically ill patients
7. Discuss early key in bed and out of bed mobility research findings, their application to practice and the patient focused outcome.
8. A step by step approach to help move evidence-based fundamental care practices into acute and intensive care environments.

Chapter Overview

In today's critical care environment, we face a difficult but essential task: to provide comprehensive, compassionate, complex, technological care without causing harm to our patients. To foster a safe patient environment it is our task to examine care practices and processes to identify and attenuate potential for error. This chapter presents the challenges with our current practice of basic nursing care and describes an Interventional Patient Hygiene Care Model for use by nurses in redesigning how we approach nurse sensitive care practices in the future to impact patient outcomes. A change framework is critical to ensure reintroduction and valuing of evidence basic nursing care in conjunction with the right resources and systems to sustain practice. Area's where critical care nurses can significantly reduce harm include preventing; skin injury, health care acquired infections, deconditioning and cognitive decline. While the list in not all inclusive, knowledge of assessment and evidence based nursing care practices will help the nurse significantly impact both short term and long term outcomes for critically ill patients.

Forces Driving Nursing Practice Change

A significant force driving change is the evidence based practice movement. Evidence based practice (EBP) is the conscientious explicit and judicious integration of the best available evidence from systematic research.[1] The challenge nursing faces in our current culture is often the misrepresentation of evidence-based practice. EBP is often considered only to be practices derived and validated with RCTs. This limited interpretation may lead to our failure to consider evidence that is better than tradition based care.

Strong forces of change include those that are driven by organizational and regulatory bodies. In the US the Institute of Medicine (IOM), the Joint Commission, the Agency for Health Care Regulatory & Quality issues (AHRQ), National Quality Forum, the Institute for Health Care Improvement (IHI) have aligned their visions to make health care environments safer and improve the quality of patients' lives.[2-5] The American Hospital Association (AHA)/Health Research & Educational Trust (HRET) Hospital Engagement Network (HEN), comprised of 31 participating states and U.S. Territories and over 1,500 hospitals. As part of the Partnership for Patients Campaign to reduce patient harm by 40 percent and readmissions by 20 percent, the AHA/HRET HEN have resulted in over 69,000 patients who had harm prevented and an estimated cost savings of over $200 million in 2012 and 2013 combined.[6]

Similar quality and financial forces exist and spread to other part of the world, the Singapore Healthcare Improvement Network (SHINe) is one of the Institute of Healthcare Improvement's (IHI) Quality and Innovation Centers (QIC). IHI described a QIC as "a leading resource and driving force for system-wide, transformative health care improvement in a system or region committed to better health, better care and lower costs.[7] SHINe is an umbrella group composed of member healthcare organizations which are collectively committed to better health, better care and lower cost care to patients. The Network aims to accelerate the pace and scale of improvement, leading to system-wide, transformative healthcare in Singapore.[8]

The Centers for Medicare and Medicaid's and third party payers are changing reimbursement structures and limiting or eliminating reimbursement for preventable errors. In the US, the economic ramifications of these changes have helped to focus the momentum on safety and avoiding preventable hospital acquired conditions.[9]

With patient safety serving as the overriding goal, there is a positive movement within the profession of nursing to "get back to the basics" or "fundamentals of care" to improve care and prevent nurse associated errors/harm such as: health care acquired infections, development of pressure ulcers and failure to rescue.[10] The majority of these nursing care practices fall into the category of hygiene and mobility interventions. So if nursing's fundamentals of practice are not routinely being employed as suggested by data on nurse sensitive outcomes, what are the reasons and what can we do about them?

One theory suggests that the basics of care may be absent or devalued because of limited structures that assure reinforcement of the importance of the basics, reward/recognition for doing them, or failure to hold nurses accountable.[11] While untested, the theory may be used by nurses to examine the value of these care practices within their work culture. This may help identify the need for a change in culture that stresses the importance of basic nursing care functions as supported by the best evidence.[12] For example, many nurses are able to identify or know when they make a medication error or failed to follow a physician's order. However, prior to the current world wide patient safety movement, most frontline critical care nurses were unaware of data related to nurse sensitive outcomes such as ventilator associated pneumonia, blood stream infection; pressure ulcer incident and urinary tract infection. These indicators are all considered nurse sensitive outcomes for the quality of nursing care delivered.[13] As noted by BF Skinner "behavior that is reinforced continues behavior that is not reinforced stops".[14] In essence, care practices, and their value, may have been "conditioned" out of the nurse. The disease focused model of diagnosis and treatment has been the dominant care delivery model within most of our acute care environments. Unfortunately, prevention of complications has been less so. It is time for our profession and each individual nurse to reclaim the fundamentals of nursing that are essential to positive patient outcomes and use evidence based practice to drive the transformation.

Interventional Patient Hygiene: Building a Usable Model

This transformational journey is similar to launching a campaign and therefore may benefit from a recognizable name and model to help ensure the transformation. Use of a model may help clarify and provide a means to articulate nursing's unique contributions to healthcare. Two categories, evidence-based interventional hygiene and mobility strategies, if placed within the context of a comprehensive program for reducing error, may help prioritize a list of care activities for critical care nurses. Positive outcomes may follow.

Webster's dictionary defines hygiene as the science of prevention of illness and the maintenance of health.[15] The goal of basic nursing care is to proactively intervene with nursing interventions that focus on using evidence-based hygiene and mobility strategies to reduce health care acquired infections and skin injuries. These hospital-associated conditions are linked to increases in patient morbidity and mortality as well as significant cost burden to our health care systems. The term "Interventional Patient Hygiene" (IPH) was created as a model for a systematic approach using evidence based nursing care interventions to prevent health care acquired conditions.[16] The components of the model include oral cleansing, patient mobility, maintenance of a central line, urinary catheter care, bathing to reduce bacterial load and skin prevention strategies.[12] Figure 1. McGuckin et al expanded the IPH model to incorporate hand hygiene and skin antisepsis.[17]

A survey was conducted to determine the knowledge base of infection preventionists and nurses related to the components of the interventional patient hygiene model. Surveys were sent to a random sample of 1178 nurses at the American Association of Critical Care Nurses National Teaching Institute and 1776 infection perventionist attending the Association of Professionals in Infection Control and Epidemiology. The response rate was 15%, representing 31% infection preventionists, 42% RN's and 37% certified critical care nurses. Results of the survey revealed an excellent knowledge base of five major components of the model; hand hygiene (96%), oral hygiene (95%), early pre-op skin prep (70%), bathing/skin care (94%), incontinence care (93%); the mobility component was not evaluated. However, the group demonstrated less knowledge about nursing interventions, as delineated in the IPH model, to prevent untoward patient outcomes.[17]

Respondents reported that they were aware of the scientific evidence supporting IPH interventions as follows: incontinence care-75%, surgical site infections -66% and ventilator-associated pneumonia-86%. Additional questions included whether the institution had an IPH policy, whether IPH information was included in orientation, and if education about the topics had been provided to all staff within the previous year. Between 35 to 49% stated their institution had an IPH policy, 42% stated it was included in orientation and that they had received education within the previous two years. The survey results suggest we have a way to go to improve the culture of nurses as it relates to "owning and acting" on IPH components that are within our scope of practice.

Securing Successful Integration of the Basics

Success in nursing's journey will be fleeting if the fundamentals are reintroduced as the basic care nurses has been performing for years or initiated as a process followed by audits alone. Instead, successful transformation begins with developing a culture that values the importance of these care practices and the evidence that supports them. While providing evidence based education, frequent motivational reminders may be inserted that reinforce the understanding that fundamental/basic care practices are core to the profession of nursing, are independent in scope and if not performed or delegated by us, may cause patient harm. This is authentic patient advocacy.[12]

However, patient advocacy by nurses is often articulated and performed within a narrow window of a single incidence where the nurse serves as the voice for the patient to ensure 'the right thing happens" and/or application of evidence based care. Nurse advocacy must reach beyond that view to encompass preventing harm within the context of all clinical practice. For example, use of a valid and reliable risk screen that is acted upon by the nurse, is an evidence based way to prevent harm. Unfortunately, often the screens are viewed as required documentation to fulfill criteria for a regulatory body versus essential to the nurses' independent role in evidence-based application of care assessment and intervention.

Numerous studies have shown that education/skill building is not enough to effect sustainable change.[18,19] Multimodal strategies that evaluate the available nursing resources and systems in order to effect change, make it easier for the clinician to achieve an effective and consistent practice. Such initiatives have shown greater success.[20-22]

Once the resources are present and systems designed to deliver the care and evaluate effectiveness, then we can truly hold the individual nurse accountable for the practice. Figure 2 illustrates the three components just described in a framework entitled "Sustaining Nursing Clinical Practice".[12] It may be used for any change in clinical practice but its application is critical for reintroduction and valuing of evidence based fundamental/basic nursing care practices. In the following sections we will be addressing nursing care practices that are independently own that have an impact on skin, infections and preventing the complications of immobility. This include skin prevention, hand hygiene, bathing, oral care, and early mobility.

Key Points

- There is a positive clinical and economic impact to performing evidence based nursing care practices

- The Interventional Patient Hygiene model connects evidence based nursing care practice to nurse sensitive outcomes creating a framework for the impact of basic nursing care

- Changing routinize behavior requires a revaluing of the care, evidence based skill and knowledge, the right resources and systems to make it easy to provide the care and then nurse can be held accountable for the practice of basic nursing care.

CHECK YOUR PROGRESS: Assess your understanding of key points from the previous sections

1. The Interventional Patient Hygiene model was design to
    a. provide additional tasks for nurses to complete
    b. strengthen the connection between nursing care & outcomes
    c. outline a structure to measure the impact of medical care
    d. demonstrate a link between infection and hand hygiene
2. Resources and systems help the nurse
    a. function more efficiently
    b. practice using the evidence
    c. provide the right care at the right time
    d. all of the above
3. Professional practice flourishes in an environment that is structurally empowered due to:
    a. innovative leadership
    b. solid structures
    c. solid processes
    d. all of the above

Answers: 1. b 2. d 3. d

Fundamental Nursing Care Practices for Patients at Risk for Skin Injuries

Pressure ulcer injuries are the fourth leading preventable medical error in the United States. Pressure ulcers cause extreme discomfort, and often lead to serious life-threatening infections. In addition to pain and suffering, one pressure ulcer results in adding four days to the length of stay independent of other risk factors. Pressure ulcers increase a patient's risk of developing a hospital-acquired infection by 25%. In-hospital death occurred in 11.6% of hospital stays with pressure ulcers noted as a secondary diagnosis, as compared to 4.2% of stays with a principal diagnosis of pressure ulcers and 2.6% of stays for all other conditions. Based on a recent systematic review of the literature, hospital acquired pressure ulcers for critically ill patients' worldwide range from 3.3% to 53.4%.[23] Is nurses knowledge regarding prevention strategies a factor in the inability to reduce hospital acquired pressure ulcers? Critical care nurses from an urban teaching hospital were administered a reliable and valid 47 item true false test to assess their knowledge level of pressure ulcer prevention and staging. Test scores were not affected by experience, educational level, or when nurses last read an article on pressure ulcers. Six-seven percent of the nurses scored below 90% on items focused on prevention.[24,25]

At Risk Population

The two major factors impacting pressure ulcer development are the intensity and duration of the pressure and the ability of the skin and supporting tissue to tolerate the pressure. As the body comes in contact with a support surface normal pressure and shear forces are generated on the skin and supporting structures below. If excessive load occurs in a short period or a lower load occurs during a longer period, a pressure ulcer will developed. In addition, there are a number of contributing or predisposing factors that are associated with pressure ulcers. At risk patients include the elderly, stroke victims, underweight patients, and patients with diabetes, dementia, wheelchair use, low perfusion states, receiving catecholamines or any patient with impaired mobility or sensation.[23] Patients with inadequate intake or an impaired nutritional status correlate well with the development of a pressure ulcer or a delay in wound healing. Moisture contributes to a weakening of the skin structure. Exposure to urinary or fecal material contributes to the development of incontinence-associated dermatitis (IAD), a potential precursor to a pressure ulcer.[26] Up to 33% of all hospitalized patients have IAD. IAD is an inflammatory response to the injury of the water-protein-lipid-matrix of the skin that is caused by prolonged exposure to urinary or fecal incontinence. Physical signs on the perineum and buttocks include erythema, swelling, ozzing, vesiculation, crusting and scaling. Patients who experience fecal incontinence have a 22 times higher risk for the development of pressure ulcers than patient who are not. When you add immobility into the equation the risk increases to 37.5 times higher.[27] Injury from friction caused by movement against a fixed surface is exaggerated if the skin is moist. Vigorous scrubbing used to remove fecal material can create friction and further injury to the skin. However, the significance of these various confounding factors has yet to be determined.[23]

Assessing Risk

Most healthcare institutions around the world perform daily systematic risk assessment for skin breakdown using such tools as the Braden and Norton scales or Waterlow scores.[23] If risk is identified, the nurse is directed to initiate evidence-based strategies to minimize or eliminate the risk. The current validated tools do not always capture all the risk factors of critically ill patients. Additional risk factors in critically ill patients are low perfusion states, receiving catecholamines, hemodynamic instability with turning, greater number of tubes and lines, severe agitation, and longer periods on non-pressure reducing surfaces while in the field, operating room or emergency room. In a recent large retrospective study, subscales of the Braden tool had greater correlation than the total Braden score (0.83 vs. 0.71).[28] Use of subscales may help in directing the clinician to evidence based strategies specific to the risk factor.[28,29] Evidence based knowledge and process change around hygiene related activities that protect the patient's skin against pressure and exposure to caustic substances are key in reducing the incidence of pressure ulcers.

General Skin Care

Caring for the patients skins during routine hygiene practices is more than just an opportunity to clean the patient. It can serve as an early warning system to identify injury to skin; a chance to assess progress in the patients healing process, improve tone and elasticity of the skin while potentially reducing the spread of microorganisms.[12,30] When you consider that aging dries skin, roughens the texture and reduces the tone and elasticity, the average hospitalize patient skin is at risk on admission. By identifying skin problems during the bath, they were able to apply prevention strategies more quickly and prevent skin problems from progressing.[30] The registered nurse needs to consider performing the bathing process with nursing personnel in order to perform additional assessments and not rob the patient of our professional expertise in identifying problems early and begin finding solutions. In addition to cleaning and assessment of the skin, the bath is an opportunity to examine a patient's muscle tone and strength, fatigue factor, range of motion and ability to participate in activities of daily living both from a physical and psychological perspective.[31,32] When we bathe another person, it allows us cross the intimacy barrier. The registered nurses can assess a patient's pain level during activity/rest and perform active listening to explore the patient's ability to cope with their illness. These assessments are lost when assistive nursing personal performs the bath alone.[12]

The bath process should not compound that risk. Washcloths industrially washed and re-used become rough in texture and may cause injury by increasing the transepidermal water loss of the skin.[33] Current soaps used with the traditional bath such as Dial, Ivory and even Septi-Soft have a pH greater than 8.5. Cleansing products should have a pH as close to natural's skins at 4.5 to 5.5 pH because this acid mantle helps reduce the potential for pathogen invasion or environmental irritants.[34-36] Natural or synthetic surfactants in soap remove the lipid layer during cleansing, compromising the natural infection barrier. In addition, bar soaps may harbor pathogenic organisms.[37,38] The traditional bath using tap water and a basin requires moisturizing after completion making it a two-step process. With a basin bath there is a potential for the basin to become a reservoir for microorganisms and cross contamination of the immediate environment and healthcare personnel.[39] Both gram-negative, gram-positive and resistant organism were identified in patient's bath basins after receiving a soap and H20 basin bath. [40-42] The bacteria release from the biofilm lining the pipes and facets may be the contributing factor to the contamination of the water.[43-44] The use of pre-packaged disposable bathing products with soft cloths, a pH balanced cleansing agent with gentle surfactants, no rinse with lotion provides a method to bath without injury and the risk for microorganism spread.[45]

Since moisture and shear/friction are two of the most significant risk factors in the development of pressure ulcers, addressing them significantly reduce the number of hospital acquired pressure ulcers seen in critically ill patients.[27,28,47] Cleansing and protecting after an incontinence episode is critical to maintaining intact skin. Incontinence can be managed effectively by following evidence based strategies that include; cleansing of the skin as soon as soiling occurs, the use of a protective cream or barrier on the skin with every soiling episode and use of incontinent pad and/or brief to absorb wetness away from the skin.[48] The ideal cleansing solution should lift irritants from the skin without damaging the acid mantle. Moisture barriers are creams or ointments alone or in combination have the following active ingredients; petroleum, dimethicone or zinc. Petroleum alone is ineffective against fecal incontinence. Dimethicone, when in combination with zinc or petroleum, serves as an effective barrier against both urine and stool. The consensus panel on assessment and management of IAD recommend a skin protectant or disposable cloth that combines a cleanser, emollient-based moisturizer, and skin protectant for prevention of IAD in persons with urinary or fecal incontinence and for treatment of IAD, especially when the skin is denuded.47 Simplifying the care process to ensure that every incontinence episode has a barrier application is key to meeting the guidelines of barrier application with each incontinent episode.23 If frequent soiling occurs, initiate care strategies for controlling the source of the moisture. External management of diarrhea can be achieved through the use of a fetal containment device or bowel management system.48-50

When using an under pad to contain moisture, the wick away properties and breathability are critical. There is no reusable pad on the market that wicks away moisture or has sufficient breathability to allow maximum benefit of airflow depending on the bed surface. Examine the type of product in use to ensure maximum protection.[51-52] Pads are not the only material we place under patients. In a study, looking at independent risk factors for pressure ulcer development in critically ill patients, mobility and the number of layers of linen on the bed were found to be significant.[53] More than four layers of linen were associated with an increase risk. This may be attributable to loss of pressure reducing or relieving effect of the mattress. The surface supporting the patient is an important component to reducing the risk for pressure ulcers. There are many types of pressure reducing/relieving surfaces. The clinical trials examining their efficacy are inconclusive as to the type of surface that provides the best benefit for the cost. They are more effective than standard mattresses in reducing pressure. A best practice recommendation is to select a support surface that meets the patient’s needs.

Consider the patients need for pressure redistribution based on their level of immobility, moisture control, shear management, size and weight and the presence of existing pressure ulcers.[23] When risk is assessed systematically, skin care prevention strategies protocolized, the support surface improved, enhancements in documentation and a comprehensive staff education program there were significant reductions in the incidence of pressure ulcer development seen.[54] Table 1 provides key evidence based prevention strategies to significantly reduce the risk for development of a pressure ulcer in a hospitalized patient.

Table 1. Key Pressure Ulcer Prevention Strategies[23] Evidence Based Prevention Strategy
Nutrition: 1. Screen nutritional status for each individual at risk or with a pressure ulcer at admission, with each significant change, when lack of healing of pressure ulcer is seen 2. Perform using a reliable and valid tool. 3. Refer patients at nutritional risk to registered dietitian or a multidisciplinary team that manages nutrition. 4. Provide individualized energy intake based on underlying medical condition.
Positioning: 1. Reposition of all individuals at risk of or with existing pressure ulcers unless contraindicated. 2. Repositioning frequency will be influenced by the individual's condition and the support surfaces in use. 3. Establish pressure relief schedules that prescribe frequency and duration.

4. Reposition the patient in such a way that pressure is relieved or redistributed and avoid positioning directly onto medical devices.
5. Foam wedges may be superior to pillows in maintaining a patient in a side lying position.
6. Use shear/friction aids for in-bed reposition and transferring to a stretcher. Inspect the skin with each repositioning event.
7. Do not leave moving and handling equipment under the individual after use unless the equipment is superficially design for that purpose
8. Avoid positioning on bony prominence as with existing non-blanchable erythema.
9. Repositioning, using the 30° semi fowlers or the prone position or the 30° tilted side lying positions if the individual can tolerate these positions, and the medical condition allows.
10. If sitting in bed is necessary, avoid greater than 30° head of the bed elevation and/or a slouch position that places pressure and shear on the sacrum and coccyx for greater than 60 minutes. Positioning with pillows under the arms may help slouching.
11. Limit the time a patient spends seated in a chair without pressure relief. (<2 hours)
12. Document the repositioning schedule including the frequency position and evaluation the outcome.

Support Surface: Is a specialized device for pressure redistribution design for the management of tissue load, microclimates and other therapeutic functions.

Support Surface and Heels

1. Select a support surface that meets the individuals needs based on immobility/inactivity, microclimate management and shear reduction, size and weight, risk of development of new pressure ulcers and number of current pressure ulcers

2. Use a higher specification foam mattress (Visco-elastic polymer foam) rather than the standard hospital foam mattress for patients assessed at risk for pressure ulcer development.
3. There is no evidence to support that one high specification foam mattress vs. another is better.
4. Use an active support surface, whether it is an overlay or mattress, for patients at higher risk of pressure ulcer development, where frequent manual turning is not possible.
5. The overlay or mattress replacement with alternating pressure active support surfaces has similar benefits in terms of pressure ulcer incidence.
6. Continue to turn and reposition whenever possible for all patients at risk for pressure ulcer development regardless of the support surface in use.
7. Choose positioning devices and incontinence pads, clothing and bed linen that are compatible with the support surface
8. Consider using a high specification reactive foam mattress or non-powered pressure redistribution support surface with individuals with Stage I, II pressure ulcers
9. Use pressure redistributing seat cushions for patients in a chair whose mobility is reduced.
10. Avoid synthetic sheep skin but natural sheep skin may help in prevention.
11. Ensure the heels are free of the surface of the bed.
12. Use a pillow under the legs to elevate the heels. This is a short term strategy for patients who are alert and cooperative.
13. For patients who are not alert & cooperative or long term care required, use a heel protecting device. The device should elevate the heel completely off the bed and distribute the weight of the leg along the calf without putting additional pressure on the Achilles tendon. For completely immobilized patients consider a device that

incorporates prevention of external rotation of the legs to prevent plantar flexion contractures.

Key Points

- The major risk factors for pressure ulcers are pressure, shear and moisture
- Assessing risk should be done daily using a reliable and valid tool
- If using Braden Scale, the subscales are more predictive of risk and can help drive the most effective prevention strategies
- General skin care should involve us of a no-rinse ph balance cleanser.
- If a patient is at risk for heel ulcer development, use of an apparatus that distributes the weight up the calf and suspend the heel is necessary. Consider choosing a device that also address external rotation of the leg.
- For in-bed mobility, consider looking at strategies that address not only the risk factors for the patient (shear, pressure and moisture) but also reducing the risk of staff injury during repositioning techniques.
- Incontinence-associated dermatitis is best prevented when cleaning incontinence with products that clean, moisture and protect.

CHECK YOUR PROGRESS: Assess your understanding of key points from the previous sections

1. A good way to assess your patient's pressure ulcer risk is to use

   a. The RISK scale

   b. empirical knowledge & clinical judgment derived from your experience with other patients with pressure ulcer.

c. a review-of-body-systems approach.

d. the Braden Scale

2. Which of the following interventions is most appropriate for preventing excessive heel damage in immobile patients after 8 hours ?

a. placing a doughnut-shaped cushion under the feet

b. device that suspends the heel & redistributes pressure up the calf

c. suspending the heels with a pillow ensuring calf support

d. flexing the knees

3. Minimally, a patient in the acute care setting should be assessed for pressure ulcer risk at least every:

a. 48 hours

b. 24 hours

c. 8 hours

d. 4 hours

Answers 1.d 2.b 3.b

Fundamental Nursing Care Practices to Prevent Healthcare Acquired Infections

The CDC healthcare-associated infection (HAI) prevalence survey provides an updated national estimate of the overall problem of HAIs in U.S. hospitals.[55] Based on a large sample of U.S. acute care hospitals, the survey found that on any given day, about 1 in 25 hospital patients has at least one healthcare-associated infection. There were an estimated 722,000 HAIs in U.S acute care hospitals in 2011. About 75,000 hospital patients with HAIs died during their hospitalizations. More than half of all HAIs occurred outside of the intensive care unit. HAI's result in significant increases in patient morbidity, mortality, length of stay, and use of health care resources.[56,57] Health-care-associated infections are deemed the most frequent adverse event threatening patients' safety worldwide.[58,59] (Burke JP, 2003 & Bates DW et al, 2009). The systematic review and meta-analysis conducted by Benedetta A. et al [60] has shown that endemic health-care-associated infection represents a major burden and safety issue for patients in the developing world, with an even greater epidemiological relevance than in developed countries.

Nursing Practice Change in the Prevention of Healthcare-Associated Infections

Nurses play a pivotal role in preventing healthcare-associated infections (HAIs), and are in the unique position to effect change to improve patient care standards. In all essence nurses should continuously re-examine care management based on new and best evidence that would result in improved patient outcomes. In fact nurses in all roles and settings can demonstrate leadership in infection prevention and control by researching for and applying evidence-based healthcare-associated infection prevention measures to reduce patient harm.

Moving the Evidence into Practice in the HAIs Prevention

In the past, infection control prevention has largely used the valid methods of applied epidemiology-active surveillance testing of specific pathogen, benchmarking, intervention, evaluation in reducing the incidence of health care-associated infections. However, the field of infection control can re-examine and translates evidence-based management strategies into clinical practice to achieve better care outcomes by selecting intervention that target a boarder array of pathogens that cause HAIs. Two global strategies, horizontal and vertical have been discussed extensively in the literature.[61,62] A horizontal approach to infection prevention and control measures refers to broad-based approaches attempting reduction of all infections due to all pathogens, while a vertical approach refers to a narrow-based program focusing on a single pathogen.[61] Horizontal approach aims to eliminate all infections and is population-based; while the vertical approach is selective of the specific multidrug-resistant organisms (MDROs).

The Vertical Approach

Multidrug-resistant organisms (MDROs) such as Methicillin-resistant Staphylococcus Aureus (MRSA), Vancomycin-resistant Enterococci (VRE) and Clostridium Difficile (C-diff) share several epidemiological features. Such MDROs transmission can occur by direct patient contact or indirect contact with contaminated equipment or environmental surfaces. As the number of colonised patients are largely asymptomatic and greatly exceeds the number of infected patients, these asymptomatic carriers can serve as the reservoir for spread to other patients. Active Surveillance Testing is used to identify patients who are carriers of these target pathogens so that these patients can be isolated from non-carriers and, in some situations, can undergo decolonization in order to eradicate pathogen carriage. The vertical approach aims to reduce colonization, infection, and transmission of specific pathogens, largely through use of active surveillance testing (AST) to identify carriers, followed by implementation of measures aimed at preventing transmission from carriers to other patients.[63] Wenzel and Edmond in the case for horizontal rather than vertical interventional programs observe a very important point as that no hospital with a vertical (MRSA) approach has shown a major reduction in the rate of all infections or of all bloodstream infections.[64] A recent analysis suggested why the MRSA (vertical) program is a flawed approach: the favourable outcomes of a horizontal program dwarf the vertical program in terms of reduced mortality, years of life lost, and costs.[64]

The Horizontal Approach

Septimus et al believes that the horizontal approach to infection prevention is still the best tactic as it benefits many pathogens and sites, especially in light of the evolution of bacterial and viral strains in an age of inappropriate antibiotic prescribing.[62] In this mode of infection prevention, the type of approach can be decided on the local level. He emphasizes that if a facility has sporadic HAIs and are not experiencing high endemic or outbreaks, then a horizontal approach provides greater value, however if rates are high with a specific pathogen, then a vertical approach short-term may be preferable.[62]

Table 1-1. Differences between Vertical and Horizontal Approaches in Infection Prevention[64]

CRITERIA	HORIZONTAL APPROACH	VERTICAL APPROACH
Approach to infection prevention & control measures	Attempting reduction of all pathogens	Narrow based program focusing on a single pathogen

Goal	Aims to eliminate all infections (population-based)	Reduce infection or colonization due to specific pathogen (pathogen-based)
Application	Generally universal	Selective and /or universal
Resource utilization	Usually lower	Typically high
Philosophy	Exceptionalism (some organisms are more important than others)	Utilitarian
Values favors	Hospital	Patient
Temporal orientation/perspective	Both for the present & future /long-term	Present/short-term
Interventions	Multipotent (Modification of HCW behavior) embraces hand hygiene, CHG bathing, care bundles and activities that reduce presentism among healthcare workers	Unipotent (Application of a technology) encompass active surveillance and vaccination of healthcare workers

Table 1-2: Evidences in the Vertical and Horizontal Approaches in Infection Prevention[62]

CRITERIA	HORIZONTAL APPROACH	VERTICAL APPROACH	EVIDENCES
Aim	To reduce the risk of infections due to a broad array of pathogens of pathogens through implementation of standardized practices.	To reduce colonization, infection, and transmission of specific pathogens through the use of active surveillance testing (AST) to identify carriers, followed by implementation of measures aimed at preventing transmission from carriers to other patients.	1) Septimus, et al.[62] "More than 100 observational studies have evaluated the use of MRSA AST to target MRSA carriers for contact precautions, with or without supplemental decolonization". 2) Huskins, et. al.,[65] a multicenter cluster-randomized, controlled trial in intensive care units (ICUs) -- demonstrated that an intervention involving MRSA AST plus universal gloving until a patient's colonization status was known to be negative - did not impact rates of MRSA colonization or infection.
HAIs Preventive Measures	Prevention strategies include : 1) Minimizing the unnecessary use of invasive medical devices 2) Enhancing hand hygiene	Used in prevention of MRSA transmission and infection	2) Jain et.al.,[66] described a nationwide intervention Veterans Affairs acute care hospitals that included MRSA AST and contact precautions for MRSA

	3) Improving environmental cleaning 4) Promoting antimicrobial stewardship 5) Decolonization of all patients in high-risk settings using topical Chlorhexidine Gluconate (CHG)		carriers, improved compliance with hand hygiene, and an institutional culture change that was temporarily association with a large decline in infections cause by MRSA as well as other pathogens.
Endemic situations	Offers best overall value target all organisms (diversity of microorganism)	Selected organism	Septimus et. al.,[62] (2014) explain that vertical approach often based on the results of AST, the rationale being that multi-drug resistant organisms (MDROs) such as MRSA, VRE, Multidrug-resistant (MDR) Gram-negative Organisms, and Clostridium Difficile (C diff) share several epidemiological features.
Mortality	Reduced	Greater	Wenzel RP et al[63]
Years if life lost	Reduced	Greater	Wenzel RP et al [64]

Decolonization of the hands of the health care worker and the skin of the patient and are two global strategies to reduce overall bacterial burden in the environment and has the potential to significantly reduce health care acquired infection.

Hand Hygiene

Human hands are the number one transmitter of healthcare-associated infections (HAIs), and effective hand hygiene is the best way to prevent infections from spreading[67,68] In a healthcare setting, practicing hand hygiene is everyone's responsibility including staff, patients, and visitors. Alcohol based hand hygiene is the first line unless the hands are visible soiled. Placement of dispensers is an important component in helping to ensure compliance of hand hygiene. Patient involvement in hand hygiene is critically important because while healthcare workers understand how hand hygiene can impact the spread of infections, it may not be as obvious for patients. WHO first global patient safety challenge, Clean Care is Safer Care is a campaign launched in 2009.[68] The goal of Clean Care is Safer Care is to ensure that infection control is acknowledged universally as a solid and essential basis towards patient safety and supports the reduction of health care-associated infections and their consequences. The Clean Care is Safer Care advocates the need to improve and sustain hand hygiene practices of health-care workers at the right time and in the right way to help reduce the spread of potentially life-threatening infections in health-care facilities. In addition to ensuring that nursing practice is evidence-based, engaging patients through education will promote better partnership in the improving care outcomes. An awareness campaign that encourages healthcare workers and patients to work together for better hand hygiene helps highlight the importance of it for everyone and keep hand washing opportunities fresh in everyone's mind. Bridging the gap between evidence and practice, and engaging health professionals and senior leadership in evidence-based infection-control practices remains an ongoing challenge. Anderson et al[69] give five common reasons for hand hygiene behaviors not being adequately adhered to. (Table 4); these provide a solid starting point to explain the complexity of hand hygiene. Vincent believes that infection prevention and control and hand hygiene are a matter of common sense, and has encourages those working in this area to consider human factors when developing approaches to educate health professionals to improve compliance with guidelines and recommendations.[70]

Table 1-3: Common Reason for Lack of Hand Hygiene

	Hand Hygiene Challenge	Rationale
1	Health professionals are asked to perform hand hygiene practice but the action does not have a direct and immediately observable result	Infections that are preventable through hand hygiene often occur days after the absence of hand hygiene. There is, on the whole, no obvious cause and-effect relationship. This affects health professionals' motivation
2	The desired outcome of appropriately timed hand hygiene action is only the lack of an undesirable outcome –infection – and this outcome is not immediately noticeable	Similarly to the point made above, as there is often no obvious positive result due to hand hygiene, it is difficult to connect action and outcome therefore impacting on health professionals' motivation
3	Tasks such as hand cleansing are sometimes perceived as not convenient	Hand cleansing is likely to be dropped or forgotten in a busy working environment. This challenge should be addressed through knowledge enhancement and "cues" to action
4	Concurrent clinical activities demand immediate cognitive and physical energy and hand hygiene is often seen as separate, not integral, to the main task	Other demanding tasks do not have delayed feedback and are often more strongly associated with positive results than hand hygiene. Again, the inability to observe the "initiation" of an infection in relation to a particular clinical task, and the invisibility of microbes, makes it difficult to keep hand hygiene part of everyday practice. This means the importance of hand hygiene must be raised on an ongoing basis
5	There are very few naturally embedded cues to prompt health professionals to perform hand hygiene within their routine workflow	A naturally embedded cue occurs during the course of a task and signals what to do next. In relation to hand hygiene, there is no physical barrier to prevent a practitioner touching a patient if a hand hygiene action has not occurred. Additionally, if hand hygiene is seen to disrupt the workflow, health professionals may purposefully skip it. Effective cues must be manufactured, tested and strategically placed
Source: Adapted from Anderson J, et. al.[69]		

Recent evidence has shown the effectiveness of clinical interventions in controlling the spread of infection can be enhanced by moving beyond conventional approaches to other aspects, such as psychology, neurosciences and ergonomics.[71] Such multifactorial approach to improving hand hygiene is grounded in behavioral and human factor science which was pioneered by the World Health Organization, 2009.

Multimodal Approach Towards Improving Hand Hygiene

Considering the factors summarized in Table 4, the WHO cautioned an approach that focuses solely on education and training, without taking into account constraints that affect appropriate placement of hand cleansing solutions, beliefs and perceptions of health professionals, and the real-life practicality. To avoid single-focused approaches, WHO has listed the following five inter-related parts of the multimodal hygiene improvement strategy and they include system change, training and education, evaluation and feedback, reminders and organizational safety climate.[68] For system change to take place it is necessary to put in place an infrastructure that allows health-care workers to practice hand hygiene successfully. It includes; access to a safe, continuous water supply as well as to soap and towels and readily accessible alcohol-based handrub at the point of care. Providing regular training on the importance of hand hygiene, based on the "My 5 Moments for Hand Hygiene" approach, and the correct procedures for hand rubbing and hand washing, to all health-care workers is critical. Monitoring hand hygiene practices and infrastructure, along with related perceptions and knowledge among health-care workers, while providing performance and results feedback to staff will help sustain improvement. Prompts as well as reminders for health-care workers about the importance of hand hygiene including appropriate indications and procedures for performing it are part of any successful plan. The most significant component for sustainable effective hand hygiene is creating an environment that facilitates awareness-raising about patient safety issues while guaranteeing consideration of hand hygiene improvement as a high priority at all levels. Active participation at the institutional and individual levels is critical. Having an awareness of individual and institutional capacity to change and improve (self-efficacy); and actively partner with patients and patient organizations will help ensure success.

Key Points

- There are two board categories of approaches to significantly impact the spread of MDRO's within the hospital; a Vertical or Horizontal approach
- The horizontal approach is reduce the risk of infections due to a broad array of pathogens through implementation of standardized practices.
- Human hands are the number one transmitter of healthcare-associated infections (HAIs), and effective hand hygiene is the best way to prevent infections from spreading
- The WHO believe that a comprehensive approach to address hand hygiene is critical for a successful campaign.

CHECK YOUR PROGRESS: Assess your understanding of key points from the previous sections

1. When would I consider using the vertical approach for reducing health care acquired infections?
    a. to reduce line and tube infections
    b. an acinetobacter outbreak
    c. to reduce C. difficile
    d. transmission of VRE
2. Wearing gloves eliminates the need to wash hands.
    a. True
    b. False
3. Which of the following agents used for routine decontamination of the hands in health care settings is most bactericidal and least irritating to the skin?
    a. alcohol-based hand rub
    b. antimicrobial soap and water
    c. chlorhexidine and wash
    d. plain soap and water
    e. triclosan handwash

Answers: 1.b, 2.b, 3.a

Patient Decolonization

The second global strategy for reducing infection prevention is the horizontal approach of decolonizing the patient through a different bathing process. Patients in intensive care units (ICUs) are at greater risk for skin colonization and infection with MDROs because of the presence of significant comorbidities, immunodeficiency's, exposure to antibiotics, and breaks in skin integrity related to the use of invasive devices. In addition, the hospital environment surfaces, tap water, sinks, and patient themselves are recognized as a significant source of transmission of bacteria and the potential spread of infection [72,73]

In most acute care facilities, nursing personnel provide baths using a basin of warm tap water, soap, and washcloths for patients who are bed bound and unable to provide self-care. The evidence supports changing the way we bathe to the use of Chlorhexidine, which is associated with significant reductions in central line-associated bloodstream infections (CLABSIs), vancomycin-resistant enterococci (VRE), methicillin-resistant Staphylococcus aureus (MRSA) colonization, and infections with MDROs.[74-81]

Why reconsider the use of soap and tap water to bathe? The development of bacterial biofilm in the hospital water distribution system and its association with cases and outbreaks of HAI is well documented.[40,43,44,82-88] In a review of the literature, 10 serious outbreaks of P aeruginosa pneumonia showed molecular ties to the water.[43] Another literature review found 9.7% to 68.1% of ICU water samples positive for *Pseudomonas aeruginosa*. When examining genotypes, 14.2% to 50% of patients' infections were found to be due to bacteria in the water at the tap versus the main supply.[44] The basin itself may serve as a reservoir. Both gram-negative and gram-positive organisms at 105 cfu/mL were identified in bath water sampled after patients received a soap-and-water basin bath.[40] The mechanical friction of bathing results in the large removal of surface epithelial cells that are released into the bath water. The skin flora of hospitalized patients differs with a larger presence of gram-negative bacilli and more antibiotic-resistant organisms.[39,45,46] In a multicenter basin sampling study in 88 hospitals in the United States and Canada, 62.2% of 1103 basins sampled were contaminated with common hospital-associated pathogens. The highest contamination rate was for gram-negative bacilli (44.9%) followed by VRE (34.9%). The lowest was MRSA with a 3.3% rate.[42] Contamination occurs through many sources, including the patient's skin flora, bacterial biofilm in the tap water, basins used for incontinence cleansing, storage of hygiene products, or emesis.[41-42,45,83,88]

Daily Bathing With Chlorhexidine

In 2006, a comprehensive study examined VRE colonization rates with 3 types of bathing; soap and water, non-medicated cloth basinless bathing, and 2% CHG-cloth bathing (off label use in USA only) [46] The CHG-impregnated cloths produced a 2.5 $\log_{10}$ colony count reduction on the skin when compared with soap-and-water bathing. The incidence of VRE acquisition was 26 per 1000 patient days with soap and water, 15 per 1000 patient days with non-medicated cloths, and a statistically significant reduction to 9 per 1000 patient days with the 2% CHG cloths. When load reduction occurred on the patients' skin, a corresponding reduction occurred on the hands of the health care worker and in the environment.[46] When evaluating the skin in the CHG group, no adverse events were found compared with patients who received soap-and-water baths which showed the highest rate of skin deterioration. A follow-up study was conducted to evaluate the impact of 2% CHG-impregnated cloths versus soap and water on CLABSI rates. A significant reduction in CLABSIs was demonstrated with CHG bathing.[39] In addition, when a 2% CHG-impregnated cloth was used for bathing, a single daily application reduced gram-negative counts for 24 hours.[73] Soap and water bathing was an independent predicator for the development of a CLA-BSI.

Numerous before and after studies have been conducted to examine the impact of CHG bathing on bacteremia's. Two meta-analyses and one systematic review of the literature on the impact of CHG bathing on CLABSI, VRE, and MRSA colonization's and infections have been conducted.[75-77] The findings show a statistically significant reduction in CLABSIs using either the 2% CHG cloth or 4% CHG diluted was found. There were demonstrated reductions in MRSA and VRE carriage and reductions in infection using mixed methods of CHG bathing.

Both methods of application demonstrated a small number of skin reactions attributable to the CHG bathing and disappeared when CHG bathing was stopped. In two of the five studies where 4% CHG bathing was used, other methods of reducing bacterial burden were studied.[89-93] Camus et al was the only study using 4% CHG method of bathing that was an RCT.[89] They used a multicenter, placebo controlled, randomized double blind study with a 2x2 factorial design. The groups included topical administration of polymyxin/tobramycin or placebo and nasal mupirocin with 4% CHG bathing or nasal placebo with liquid soap. The patients received polymyxin/tobramycin alone, mupirocin/4%CHG alone, either regimens or all placebos. They measured impact on all types of ICU acquired infections. The results showed a significant reduction in infections when the combine regimens were used. There was no difference in infections between each regimen alone. Gould et al used 4% CHG bathing in combination with nasal anti-MRSA preparations.[90] Overall MRSA infections decreased by 3-fold but no difference in MRSA bacteremia's were seen. There was a significant decrease in coagulase-negative staphylococcal bacteremia's during the intervention period. Seven studies used a 2% CHG-impregnated cloths for bathing demonstrating significant reductions in CLABSIs in the ICU and one study demonstrating reduction in CLABSI's outside the ICU. [75]

Prospective Randomized Trails with CHG Bathing

To date there have been 3 large randomized controlled studies examining the impact of no-rinse 2% CHG cloths in comparison to soap and water bathing or no-rinse non-medicated basinless bathing. Two of the studies were conducted with adults and one with children greater than two months of age. Two focused strictly on the type of bathing and impact on colonization, infection and reduction in bacteremia's. The most recent study examines the impact of different isolation and clinical management methodologies on MRSA infection and CLA-BSI's. Milstone and colleagues using a cluster randomize 2-period cross over trial in 10 pediatric ICUs in five hospitals measured bacteremias during 2%CHG cloth bathing compared to routine bathing with either a non-medicated bath cloth or soap and water bathing with 4947 pediatric ICU patients greater than two months of age. They found the protocol population had a 36.5 lower risk of developing a bacterima when bathed with 2% CHG cloth versus standard bathing practices. There were no study related adverse events and the incidence of skin reactions was 1-2 per 1000 patient days with a greater number in the treatment group. Upon examination treating clinicians only attributed 12 skin reactions to the CHG bathing.[79] Climo and colleagues performed a cluster-randomized cross over study comparing 2% CHG cloth bathing with non-antimicrobial basin-less cloth bathing with 7727 patients in 9 ICU's and a bone marrow transplant area. The results demonstrated an overall rate of MDRO acquisition was 5.10 cases per 1000 patient days with CHG cloth bathing and 6.60 cases per 1000 patient days with nonantimicrobial cloth bathing ($P = 0.03$).[80] These rates are comparable to a 23% reduction in new acquisition of MDROs in patients bathed with a CHG cloth. The rate of hospital-associated bloodstream infections decreased 28% using CHG bath cloths. The effect was greater in patients who were in the unit longer. For the first time, the incidence of primary bloodstream infections caused by fungi was reduced by 53% with a trend toward significance. The incidence of skin reactions in both groups was monitored daily. In the patients receiving 2% CHG cloth bathing 78 patients out of 3870 experienced a skin reaction whereas 130 out of 3842 experience a reaction with the non-medicated cloth. All were considered to be unrelated to the bathing intervention. MRSA and VRE isolates did not show any high level resistance to CHG during the study. It has been suggested that the reduction in BSI's was solely due to a lower frequency of positive blood cultures due to skin organisms. However, this does not explain the reduction in fungal CLA-BSI.

Huang and colleagues conducted a pragmatic (usual conditions) cluster randomized control trail of 74,256-patients in 43 hospitals in 16 states to evaluate the best methods for reducing the spread of MRSA clinical isolates and infections within the ICU.[81] Patients were randomized to one of three study protocols; Group 1: Implementation of MRSA screening and if positive isolate the patient; Group 2: Targeted decolonization where the patients were screened for MRSA, if positive they were placed in isolation and decolonized with twice daily mupricin in the nares for five days and a 2% CHG cloth bath till discharge from the ICU and Group 3; Universal decolonization with daily bathing using 2% CHG-impregnated cloths and twice daily nasal mupirocin ointment for 5 days. The universal decolonization resulted in significantly greater reductions in infections compared with either group. A 37% reduction in MRSA clinical cultures and a 44% reduction in blood stream infections from all pathogens was demonstrated. Seven adverse events were reported from group 2 and 3. They all involved mild pruritus or rash after CHG bathing and resolved on discontinuation of use.

While the three RCT's did not experience significant allergic reactions, a rare few have been reported in the literature.[94-96] With widespread adoption, bathing with CHG could create the development of possible resistance. Recent studies show that the resistance in the US is rare but does occur.[97-100] A study examining MRSA isolates and gene encoding were tested for CHG susceptibility. The results demonstrated a type of isolate to have a higher CHG minimum inhibitory concentration (MIC) with slower reduction rates of MRSA BSI in patients with that isolate. In vitro, resistance to CHG has been demonstrated but application to clinical relevance is not clear.[98] Potential resistance remains a concern and needs to be watch overtime as the CHG bathing practice is adopted. In addition, the ability to deliver the preventive treatment (bathing) consistently to deliver CHG and prevent skin injury, the best evidence appear to support adoption of 2% CHG cloth bathing with ICU patients. A modified protocol of the bathing procedure used in the Huang study is outlined in Table 5.

Table 5: 2% CHG Cloth Bathing[101]

Bathing Procedure:

- No-rinse Ph. balance cleanser to wash the face
- Remove one cloth at a time (use 6 or 8)
- Warming is for patient comfort, it is not required.
- Cloths should be used to bathe the skin with firm massage.
- Do not use CHG above the jawline
- Ensure thorough cleaning, with special attention to commonly soiled areas such as the neck, skin folds, and perineal areas.
    - CHG is safe to use on perineal areas, including external mucosa.
    - CHG is also safe for superficial wounds, including stage 1 and stage 2 pressure ulcers
    - Okay to bathe over occlusive dressings
- After bathing the skin, clean 6 inches of all tubes/Foley nearest patient.
    - CHG is safe on lines, tubes, and devices

- CHG should be used for incontinence care, or for any other reasons for additional cleaning
    - If incontinence occurs, wipe the affected area with under pad. Then clean skin with CHG cloths.
    - Use CHG-compatible barrier products if needed
- Do not rinse with water or wipe off
- Dispose of all cloths in the trash. Do NOT flush.

Key Points

- Bathing with soap and water is an independent risk factor for the development of a CLA-BSI.
- Skin decolonization is a horizontal approach to infection prevention.
- Three large cluster randomized RCT's showed that CHG bathing with a 2% cloth was safe and effective in reducing colonization of MDRO's and CLABSI infections.
- CHG should not be used above the jawline.
- As CHG bathing/decolonization is adopted in the ICU's, monitoring for potential resistance is important.

CHECK YOUR PROGRESS: Assess your understanding of key points from the previous sections.

1. The decision to use 2% CHG prepackaged clothes versus 4% CHG liquid with a bath basin for bathing should include consideration of which of the following?
    a. Provides best reduction in MRSA infections
    b. Time requirements
    c. Increase of bacterial resistance

d. Availability of a clinical support

2. What area of the body should CHG not be used on?

    a. Perineal area

    b. Buttocks

    c. Near the eyes

    d. Skin folds

Answers: 1.a, 2.c

Oral Hygiene to Reduce Hospital Acquired Pneumonia

Management of Oral Colonization

The oral cavity is a significant source of bacterial colonization.[102] Within 48 hours of admission to the hospital, the normal oral flora changes to a predominance of gram negative bacilli and Staphylococcus aureus which places them at risk for VAP. In a study looking at 89 critically ill patients, microbiological colonization of the oropharynx was examined throughout the patients intensive care stay. The study compared pathogens in the oral cavity to pathogens causing VAP using pulsed field gel electrophoresis to compare chromosomal DNA. Out of thirty-one cases of VAP's, twenty-eight patients revealed an identical DNA match of the pathogen in the oral cavity to the pathogen causing the pneumonia.[105] Using a similar methodology, a recent study by El-Solh et al examined baseline dental plaque scores and microorganisms within the dental plaque of 49 elderly nursing home residents admitted to the hospital. Fourteen of the forty-nine patients develop pneumonia. Ten of the fourteen patients showed an identical match of pathogens in the oral cavity and the organism causing the pneumonia via DNA analysis[106]. Salivary flow is a natural host defense in facilitating the removal of plaque and microorganisms. Mechanical ventilation often promotes dry mouth or reduced salivary flow, contributing to plaque accumulation and decreased production of salivary immune factors.[107,108] The major immune factor in saliva is IgA. It's role is to protect the upper airway by limiting to absorption and penetration of microorganisms.[109] The equipment we used to remove oral secretions as well as suctioning of the endotracheal tube may contribute to the colonization of the oral cavity. In a study examining equipment used to suction excess secretions from the oral cavity, 94% of tonsil suction devices were colonized within 24 hours.[110] In another study, 80% of the tonsil suctions yielded cultures with 1 or more pathogens with a percentage being resistant organism. [111]

Prior to the current patient safety initiatives to reduce ventilator associated pneumonia, the routine practice of oral care in the critically ill patient was sporadic. Many nurses mixed their own solutions or used tap water or mouthwash with a sponge to clean the oral cavity. Lemon glycerin swabs in some parts of the world are still in use and have been found to damage the oral cavity by over stimulating the salivary gland and drying out the mouth.[112,113] In the past oral care was not perceived as a high priority. However, in a more recent study of 102 intensive care units looking at oral care practices, 91% of 556 respondents perceived oral care as a high priority.[114] A recent US survey showed that ICU units had oral care policies but practices did not always match.[115]

Numerous before and after studies and randomize controlled trials have demonstrated that implementation of a comprehensive oral care program with education shows a significant reduction in ventilator associated pneumonia, however protocol variation is significant.[116-119] Cuccio and colleague designed a protocol for all vented patients that consisted of every six hour brushing, cleansing, suctioning and moisturizing. The cleansing solution was .12% CHG. With education and compliance monitoring, VAP rates were reduced by 63%. [116]

Brushing is an essential component of effective oral care to remove plaque and prevent the development of the protective biofilm.[120] Foam swabs are limited in their ability to remove plaque from sheltered areas or between teeth. A recent systematic review and meta-analysis of RCT’s on the impact of oral care with or without tooth brushing found no difference in VAP and other clinical outcomes important for ventilated patients. With limited relevant studies, the authors caution about implementing findings until a large scale RCT’s are performed.[121] The use of chlorhexidine oral rinse (CHG) twice daily as a minimum should be part of a comprehensive oral care program for ventilated patients to reduce the incidence of VAP.[122,123] It was recently added to the Institute for health care improvement ventilator care bundle.[124] Provodine-Iodine effect as an oral cleanser to reduce VAP remains unclear.[123] CHG rinse has been shown to significantly reduce gram negative, gram positive and virus colonization of the oral cavity for a sustain period of time.[125] Evidence supports that toothpaste interfers with CHG effective so a separation of 2 hours between brushing and rinsing with CHG should occur.[126] Recent data is debating the concentration of CHG to be used. 2% CHG may be superior however studies are limited to the cardiothoracic surgery patient.[120]

Patients not on a ventilator are still at risk for pneumonia. An analysis of the Pennsylvania Patient Safety Authority shows that NV-HAP occurs more often than VAP and there is no significant difference in mortality. Therefore, NV-HAP is costing more lives and dollars than VAP.[127] Just as ventilated patients require frequent oral care to help prevent pneumonia, non-ventilated patients also require oral care. Studies in nursing homes show that oral care can reduce the incidence of pneumonia in elderly patients. Yoneyama's study included 11 nursing homes in Japan over a 2 year period of time.[128] One hundred and eighty-four residents received an enhanced oral care program that included tooth brushing after each meal and a weekly review by a dentist or hygienist while 182 residents received normal oral care. The enhanced oral care group experienced fewer febrile days ($p<.01$), fewer cases of pneumonia ($p<.05$), and lower mortality ($p<.01$) than those who did not receive the enhanced oral care program. In another nursing home study by Watando, not only did oral care reduce healthcare-acquired pneumonia, there was also an improvement in the swallowing and cough reflex sensitivities, factors that could also help to prevent pneumonia.[129] A pilot study by Quinn, et. al. demonstrated that increased frequency of oral care for non-ventilated adult patients in an acute care hospital reduced NV-HAP by 37% over 12 months.[130]

There are no documented studies that show the optimal frequency of oral care for non-ventilated patients. For the general public, the American Dental Association (ADA) recommends brushing twice daily with a soft-bristled toothbrush using therapeutic toothpaste, and rinsing with an antiseptic rinse.[131] If the non-ventilated patient cannot manage oral secretions and is high risk for aspiration, the caregiver may consider using a suction toothbrush, similar to those used in the ventilated patient setting.

Key Points

- The oral cavity is a significant source of bacterial colonization
- Patients micro aspirate even with the head of bed elevated at 30 degrees
- Implementation of a comprehensive oral care program with education shows a significant reduction in ventilator associated pneumonia
- CHG rinse has been shown to significantly reduce gram negative, gram positive and virus colonization of the oral cavity for a sustain period of time.

CHECK YOUR PROGRESS: Assess your understanding of key points from the previous sections.

1. Problems with oral health are associated with which of the following?
    a. Cardiovascular disease, poor glycemic control, and preterm delivery
    b. Upper respiratory infections, pneumonia, and gastroesophageal reflux disease (GERD)
    c. Endocarditis, arthritis, and poor glycemic control
    d. Cardiovascular disease, GERD, and endocarditis
2. Which of the following is one method to reduce microorganisms in the oral cavity?
    a. Swish and swallow with mouthwash
    b. Frequent suctioning of the oral cavity
    c. Administration of intravenous antibiotics
    d. Keeping the head of the bed at a 90º angle

Answers: 1.b, 2.b

Early Mobilization to Reduce Complications of Immobility

A strong body of evidence supports the importance of early mobilization of critically ill patients to enhance recovery and to prevent significant short and long term complications. [132-136] The short term negative outcomes for critically ill patients included ventilator and hospital acquired pneumonia, delayed weaning related to muscle weakness and the development of pressure ulcers.[137] The major long term complication is the impact on quality of life after discharge are due ICU acquired weakness and delirium that frequently occurs during an ICU stay.[138-143] ICU acquired weakness (ICU-AW) is defined as a syndrome of generalized limb weakness that develops while the patient is critically ill and for which there is no alternative explanation other than the critical illness itself.[141] The Medical Research Council Scale (MRC) score averages <4 across all muscles tested. Twenty-five percent of patients with prolonged mechanical ventilation will develop ICUAW. It is caused by critical illness polyneuropathy and myopathy or a combination of both. The major risk factors include; severe sepsis, duration of mechanical ventilation, length of ICU stay, systemic inflammatory response syndrome, multiple organ failure, immobility and use of corticosteroids/neuromuscular blockers.[141,142] ICU-AW results in prolong mechanical ventilation, reoccurring respiratory failure, ventilator associated pneumonia, increase ICU and hospital length of stay and increased mortality.[141] Up to 78% of ICU survivors experience neurocognitive impairments. A recent multicenter RCT in medical-surgical ICU's examined 821 patients with acute respiratory failure and or shock for the presence of delirium while in the hospital and the cognitive impact three and twelve months post discharge. They found 72% of patient developed delirium during their hospital stay. The duration of delirium correlated to impairment 3 and 12 month out of hospital. One out of four patients had cognitive impairment at twelve months.[143]

Herridge et al looked at outcomes of Acute Respiratory Distress Syndrome (ARDS) survivors and found that they lost 18% of their body weight at discharge from the ICU and experienced significant functional limitations at one year due to muscle wasting and fatigue[144]. In a systematic review of quality of life (QOL) data on critically ill survivors when compared to population norms matched to sex and age, evidence of challenges in physical activity and physical role functions was significant and persistent. The factors contributing to negative QOL outcomes included impaired pulmonary function, loss of muscle, proximal weakness and fatigue.[145]

Impact of Immobility on Organs

During bed rest or immobility negative effects are seen on the respiratory, cardiovascular, integumentary and musculoskeletal systems.[146-150] The major consequences to the respiratory system include development of compression atelectasis from the dependent edema formation in the supine position, impaired ability to clear the tracheal bronchial tree due to position dependent changes in the mucocilliary escalator, cough reflex and drainage thus placing the immobilized patient at greater risk for ventilator associated or hospital acquired pneumonia.[146,150] The changes in the cardiovascular system related to bed rest are significant. The act of lying down shifts 11% of the total blood volume away from the legs with the majority going to the chest. Within the first three days of bed rest there is an 8 to 10% reduction in plasma volume with the loss stabilizing to 15 to 20% by the fourth week.[146-149,151-153] These changes result in increased cardiovascular workload, elevated resting heart rate and a decrease in stroke volume with a reduction in cardiac output. Orthostatic tolerance deteriorates rapidly with immobility with the maximum effect seen at three weeks. Baroreceptor dysfunction, changes in autonomic tone, and fluid shifts are thought to be the cause. [146,154,155] The heart muscle itself becomes de-conditioned with bed rest. In healthy individuals on five days of bed rest, insulin resistance and microvascular dysfunction are seen.[151]

The skin does not normally bear weight so with bed rest, skin breakdown and delayed wound healing are frequently seen. [23] Interruptions in the skin barrier place the critically ill patient at greater risk for health care acquired infections. The musculoskeletal system is severely affected by immobility and bed rest as described above. Immobility in the critically ill patient leads to decreased muscle protein synthesis, increased catabolism of the muscle and decreased muscle mass that is more pronounced in the lower limbs.[155-159] The muscle groups that lose the most strength are those involved in maintaining posture, transferring activities and ambulation.[141] Skeletal muscle strength may decline 1 to 1.5% per day of strict bedrest.[155] In a study, researchers found that more than one third of patients with stays in the ICU greater than two week had at least 2 functionally significant joint contractures.[160] Contractures during the ICU stay was associated with higher mortality and limited function more than three years post ICU stay. Since the consequences of immobility/bed rest are so severe, mobilizing critically ill patients early has significant merit.

Overcoming Challenges to Early Mobilization

The benefits of exercise result in improved muscle strength, evidence of reduced oxidative stress and inflammation in addition to positive mood changes, shorter days in delirium, less fatigue and a greater ability to resume activities of daily living.[162-164] However, the importance of positioning and mobility as a priority of practice can be a challenge in the ICU. One study demonstrated that during an eight-hour time frame, less than 3 % of critically ill patients were turned in accordance with the standard of practice of every two hours. Close to 50% of patients during that same time period had no body position change.[165] In a study of the positioning of critically ill patients over a 2-day period in 40 ICUs in the United Kingdom, the average time between manual turns was 4.85 hours with a standard deviation of 3.3.[166] If there are challenges with repositioning in bed, what will it take to routinely achieve walking of ventilator patients? Directors of medical and mixed medical surgical ICUs in 4 countries were randomly selected to be surveyed about early mobility (EM) practices. A total of 833 ICU's (US 396; France 151, UK 138, Germany 148) provided results. Twenty seven percent reported having a formal EM protocol, while 21% had adopted EM practices without a protocol. Over 52% of the ICU's surveyed had not adopted any EM practices. Factors associated with EM practices included presence of multidisciplinary rounds (USA), written daily goals (USA, Europe), and sedation protocols (USA, Europe). Sites with protocols reported seeing reductions in length of stay and improved patient satisfaction.[167] In a recent one day point prevalence study on early mobilization of mechanically ventilated patients in 116 ICU's in Germany they showed only 24% of patients were mobilized out of bed and the majority of those patients were receiving non-invasive ventilation. The major barriers included cardiovascular instability and deep sedation.[168]

Mobilizing the critically ill patient must be viewed along a progressive continuum based on readiness, specific pathology, strategies to prevent complications and ability to tolerate the activity/movement and driven by a protocol.[137,146] Progressive mobility is defined as a series of planned movements in a sequential manner beginning at a patient's current mobility status with a goal of returning to his/her baseline.[168] It encompasses a variety of positioning and mobility techniques including; head of the bed elevation; passive and active range of motion; continuous lateral rotation therapy (CLRT) and prone positioning if indicated based on protocol criteria; movement against gravity; physiologic adaptation to an upright/leg down position; chair position; dangling and ambulation.[168] We can combat the physical de-conditioning that occurs with bed rest by using a stepwise mobility progression program. Figure 3 Mobility readiness should be assessed daily to determine status for entrance into a progressive mobility protocol or advancement within the protocol.[170] Figure 4

The challenges to mobilizing the critically ill patient include; concerns about the safety of tubes and lines, hemodynamic instability, amount of personal and equipment resources needed, current sedation practices, patient size, patient pain and discomfort and the time, valuing and priority of mobilization.[137,170-176] Safety regarding the activity event and the patient's ability to hemodynamically tolerate the movement may be the most significant.[173] Numerous studies have shown the practice of early mobility to be safe and effective.[132-136,174,176]

Hemodynamic instability can be a significant barrier in the start or progression of a mobility protocol. When individuals change their gravitational reference from a lying to sitting position the body goes through a series of physiological adaptations to maintain cardiovascular homeostasis. When the body's gravitational plane changes, the cardiovascular system normally tries to adjust in two ways: by plasma volume shifts that may cause transmission of messages to the autonomic nervous system to change vascular tone or by inner ear or vestibular response that affects the cardiovascular system during a position change.[177,178] Critically ill patients commonly have poor vascular tone, a dysfunctional autonomic feedback loop, and/or low cardiovascular reserve. Frequently, they are left in a prolonged stationary position and establish a "gravitational equilibrium" over time, making it more difficult to adapt to a position change. For patients who develop hemodynamic instability with a manual turn, the solution might be to train them to tolerate a position change versus leaving them in a stationary supine position. Rotational therapy can gradually retrain patients to tolerate turning or we can slow down the patients' movement during the mobility technique to allow adaptation.[179] Most critically ill patients take five to ten minutes to adapt to a mobility action or a position change. After the appropriate time period, the critical care nurse and/or team can safely judge pulmonary and cardiovascular tolerance to the activity and can make a determination as to whether the patient is ready to be progressed. Figure 5

Significant problems are created for ICU patients when they are not mobilized effectively. The solution rests in working as a team to increase the awareness of the importance of early mobilization and in shifting the ICU culture from one in which the patient on bed rest is the norm to one in which mobilization enables the prevention of complications and faster healing and recovery.[170,180] Mobility is a fundamental nursing activity that requires knowledge and skill to effectively apply to critically ill patients. When mobility is a core component of care it enhances key patient outcomes.

Key Points

- The major long term complication is the impact on quality of life after discharge are due ICU acquired weakness and delirium that frequently occurs during an ICU stay.
- Orthostatic tolerance deteriorates rapidly with immobility with the maximum effect seen at three weeks. Baroreceptor dysfunction, changes in autonomic tone, and fluid shifts are thought to be the cause.
- Progressive mobility is defined as a series of planned movements in a sequential manner beginning at a patient's current mobility status with a goal of returning to his/her baseline.
- Mobilizing the critically ill patient must be viewed along a progressive continuum based on readiness, specific pathology, strategies to prevent complications and ability to tolerate the activity/movement and driven by a protocol.

- Numerous studies have shown the practice of early mobility to be safe and effective.

CHECK YOUR PROGRESS: Assess your understanding of key points from the previous sections.

1. Factors that contribute to a patient experiencing orthostatic intolerance;
    a. Loss of autonomic tone
    b. Prolonged bed rest
    c. Diabetic neuropathies
    d. All of the above
2. What is the major long-term complication resulting from the physical deconditioning that takes place during a patient's stay in the intensive care unit (ICU)?
    a. Loss of orthostatic tolerance/disturbed equilibrium
    b. Onset of depressive mood disorders
    c. Diminished quality of life after discharge
    d. Increased susceptibility to autoimmune disorders
3. Progressive mobility is defined as a series of planned movements in a sequential manner with what final goal?
    a. Returning to the patient's baseline level of mobility
    b. Achieving 75% of the patient's pre-ICU activity level
    c. Prevention of ventilator- and hospital-acquired pneumonia
    d. Patient's ability to ambulate for a distance of at least 100 feet by the time of ICU discharge
4. What was the main cause of functional limitations occurring in patients within 1 year after discharge from the ICU?
    a. Heart muscle deconditioning

b. Skin breakdown/delayed wound healing

c. Joint contractures

d. Muscle wasting

Answers: 1.d, 2.c, 3.a, 4.d

Moving the Evidence into Practice

Moving the latest evidence into our fundamental nursing practices may be challenging and is best accomplished by using an organized approach. Step 1 involves performing an initial assessment of the current practices in prevention of skin injury, hand hygiene, bathing/decolonization, oral care and early mobility. Identification of practices that are not evidence based is essential. Step 2 encompasses consolidation of current hygiene and mobility practices under the framework of a comprehensive interventional patient hygiene. Measurement of baseline data using standard definitions for health care acquired pneumonia, pressure ulcer incidence rate, blood stream infection rates, symptomatic urinary catheter infection rates and incontinence associated dermatitis are key to monitoring progress or lack thereof. The value of these care practices are highlighted with the staff by sharing the scientific evidence and eliciting their participation in the establishment of protocols and guidelines. Using a shared decision-making model, step 3 contains selecting processes and products that help support compliance of the protocols and help nurses consistently do the right thing in an efficient manner.[181,182] Step 4 is implementation of the change. Post implementation rates are measured after ensuring sufficient compliance with practice changes. Results are then compared against baseline data, regional and national benchmarks if available. The final step is the continued measurement of compliance on a quarterly basis until the new practice becomes part of the routine. Essential to the success of the process is to ensure ownership and participation of all key practitioners. This will allow the change to become real and permanent. The goal is to weave the new care practices into the fabric of the unit/organization to create a safer patient environment.[183.184]

Summary

We are responsible for assuring that our current nursing and unit work cultures value and incorporate hygiene care practices and mobility activities as they are fundamental and independent care components of nursing. When implemented, using available evidence, they can significantly improve patient outcomes. The IPH model described in the paper, the change framework and the latest evidence are tools for the caregiver to begin the discussion, revaluing, education, resource attainment and systems development to ensure evidence based transformation of nursing care. It is time to reclaim and demonstrate the importance of the consistent delivery of the basics of nursing care.

End of Chapter Multiple Choice Questions

1. Fundamental nursing care practice has limited impact on patient outcomes in the ICU.
    a. True
    b. false
2. When implementing a new practice, the best strategy for success is?
    a. Education
    b. Process and product change
    c. Feedback/accountability
    d. All of the above
3. What is the most common reason a patient gets a pressure ulcer
    a. Patient is a smoker.
    b. Patient is very thin.
    c. Patient is incontinent
    d. Patient has an alter level of consciousness

4. A shearing force can occur when a patient:
    a. bumps an elbow against a hard surface
    b. gets a blister on the heel from rubbing
    c. slides down when sitting in bed
    d. all of the above
5. Using a turn sheet to reposition or move a patient can help to prevent friction and shearing forces.
    a. True
    b. False
6. The strain at which the skin breaks when there is excess moisture is?
    a. no different
    b. 4x greater
    c. 10x greater
    d. 15x greater
7. Strategies for the prevention of IAD include all the following except?
    a. wick away incontinent pad
    b. application of a barrier
    c. a diaper
    d. cleaning quickly
8. Which of the following support best practice in reducing shear and moisture injury for bedridden patients unable to move?
    a. non-breathable turn sheet, wick away incontinent pad, pillows, incontinent barrier
    b. breathable turn sheet, wick away pad, foam wedges, incontinent barrier

c. pillows, breathable turn sheet, incontinent barrier, reusable incontinent pad

d. foam wedges, non-breathable turn sheet and incontinent barrier, wick away incontinent pad

9. The head of the bed should be maintained at the lowest degree of elevation (no higher than 30 degrees) consistent with the medical condition.

   a. True

   b. False

10. What is the *most* important strategy the healthcare worker can use to prevent hospital-acquired infections

    a. isolation of patients with a resistant organism

    b. reduce the number of invasive lines

    c. sterilization of all patient related equipment

    d. handwashing

11. Which of the following is not a risk factor for the development of a ventilator associated or hospital acquired pneumonia?

    a. inadequate oral care

    b. immobility

    c. placement of a central line

    d. delay in feeding

12. Which of the following patient findings increases the risk of microorganisms entering the lower respiratory tract?

    a. An increased gag reflex

    b. Increased pooling of secretions in the oropharynx

    c. Increased mucocillary clearance of secretions

d. Increased cough

13. Immobility contributes to which of the following pulmonary complications;
    a. Pleural effusion
    b. Thin secretions
    c. Hospital acquired pneumonia
    d. Pulmonary edema
14. In the study examining position change every 15 minutes over an eight hour period, approximately what percentage of time was every 2hr turning achieved with critically ill patients?
    a. 20%
    b. 3%
    c. 10%
    d. 40%
15. Which of the following are evidence based outcomes demonstrated when successful early progressive mobility program are put in place?
    a. decrease incidence of delirium and greater ability to perform ADL's on discharge
    b. shorter ICU lengths of stay and increased incidence of delirium
    c. greater ambulation distance and longer lengths of ICU stay
    d. decreased incidence of delirium and lower patient satisfaction
16. Which of the following is considered a major barrier by nurses in performing in-bed and out of bed mobility for critically ill patients?
    a. patient refusal
    b. vasoactive drips
    c. hemodynamic instability

d. patient in pain

Answers: 1.b, 2.d, 3.c, 4.d, 5.a, 6.b, 7.c, 8.b, 9.a, 10.d, 11.c, 12.b, 13.c, 14.b, 15.a, 16.c

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Chapter 2

Acute and Critical Stroke Care

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Learning Outcomes

After completing this chapter you will be able to:

1. Identify the incidence and impact of stroke in the community
2. Describe the major anatomical areas of the brain and the major arterial vessels within the brain.
3. Classify the mechanisms of stroke and the symptomatology of stroke depending on the location of the brain ischemia.
4. Describe the immediate and ongoing care requirements and options available to a patient suffering an ischemic or haemorrhagic stroke.
5. Describe the important pharmacological agents associated with stroke care including key safety precautions and considerations to avoid further harm.

Definitions

ACA – anterior cerebral artery

AcomA – anterior communicating artery

AF – atrial fibrillation

aSAH – aneurysmal subarachnoid haemorrhage

AVM –arteriovenous malformation

BP – blood pressure

BiPAP - bi-level positive airway pressure

CO2 – carbon dioxide

CPAP – continuous positive airway pressure

CPSS - Cincinnati Pre-hospital Stroke Scale

CN – cranial nerve

CNS – central nervous system

CSF –cerebrospinal fluid

CTA - computed tomography angiogram

CTP - computed tomography perfusion

DOAC – direct oral anticoagulant

ECR – endovascular clot retrieval

ED – emergency department

EOM - extra ocular movement

EVD – external ventricular drain

GCS – Glasgow coma scale

HOB – head of bed

HT – hypertension

IV t-PA - intravenous tissue plasminogen activator (alteplase)

MRI - magnetic resonance imaging

NIBP – non invasive blood pressure

NIHSS - National Institutes of Health Stroke Scale (NIHSS)

NCCT - non contrast computed tomography scan

IPH - Intraparenchymal haemorrhage

LOC – level of consciousness

LAPSS - Los Angeles Pre-hospital Stroke Scale

MASS - Melbourne Ambulance Stroke Scale

sICH - symptomatic intracerebral haemorrhage

TIA – transient ischemic attack

VTE - venous thromboembolism

WHO – World Health Organisation

Introduction

Stroke carries a global disease burden with more than 15 million strokes occurring worldwide each year. In the United States of America (USA), a stroke occurs every 40 seconds (1, 2). Stroke is the greatest cause of major disability in the United Kingdom (1), and in Australia more than half of all stroke survivors are left with permanent disability (3). The long-term cost of caring for stroke patients is immense. In 2010 in the USA alone, the cost exceeded $70 billion (2), this cost is substantially higher in low- and middle-income areas.(4). The World Health Organization (WHO) reports these extreme costs may result in increased mortality and morbidity rates in low socioeconomic countries (1).

Stroke is a clinical condition characterized by the sudden interruption of the blood supply to the brain, retina, and/or spinal cord (5). It is a vascular disease, caused by a blocked artery (ischaemic stroke) or a burst blood vessel (hemorrhagic stroke). A stroke disrupts blood flow, thereby limiting the supply of oxygen and nutrients, resulting in tissue death (1). Stroke classically produces a sudden onset of neurological symptoms, most commonly unilateral in nature, which can be ascribed to specific vascular territories. The scope and severity of stroke symptoms can range from mild to severe. Even if symptoms resolve, tissue death may still have occurred (5). Stroke symptoms which spontaneously resolve with no infarction may be diagnosed as either a transient ischemic attack (6), or in the case of thrombolytic treatment, an aborted stroke (7). Acute stroke is a time critical medical emergency; there are a limited number of treatment options available, and most have a set time frame in which treatment must be initiated. Seeking urgent medical care at a designated Stroke Centre hospital is paramount to achieve best possible outcomes (5, 8).

Anatomy

The Cerebrum

The cerebrum makes up 80% of the brain's weight and is divided into right and left hemispheres (9, 10). It consists of an outer layer of grey matter called the cerebral cortex, and a subcortical white matter layer. Subcortical axons are responsible for conducting impulses from the grey matter to other regions of the Central Nervous System (CNS).

The cerebral cortex is divided into 4 lobes: frontal, parietal, temporal and occipital. The frontal lobes are separated from the parietal lobes by the central sulcus and from the temporal lobes by the lateral (Sylvian) fissure. The parietooccipital fissure divides the parietal lobes from the temporal and occipital lobes. (*Figure 1*)

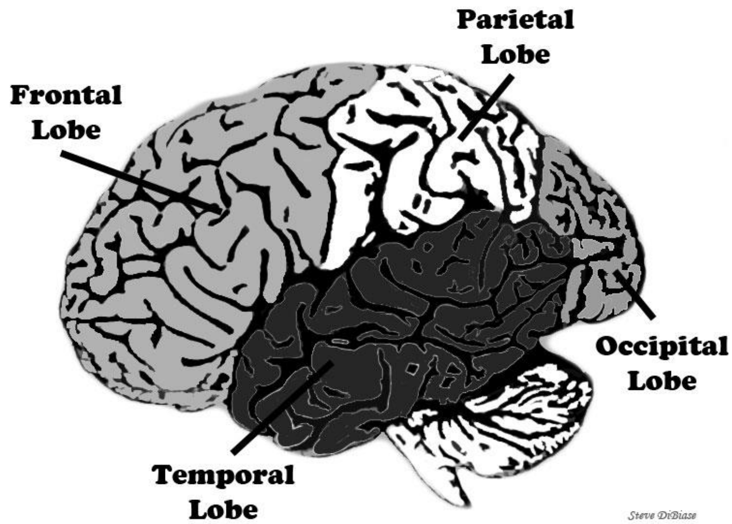

Figure 2-1: The four lobes of the cerebral cortex. Reprinted with permission from NET SMART (www.learnstroke.com), Health Outcomes Institute, LLC.

Primary functions of the cerebral cortex include language, motor control, sensation recognition and intellect – functions that are unique to Homo sapiens. In 1909, Dr Korbinian Brodmann, a German neurologist attempted to localize these cortical functions by mapping their specific regions. Brodmann's Classification of the Cerebral Cortex is incomplete, but the mapped areas allow us to gain a greater appreciation of brain function and the implications of cortical stroke damage (11)(*Figure 2*).

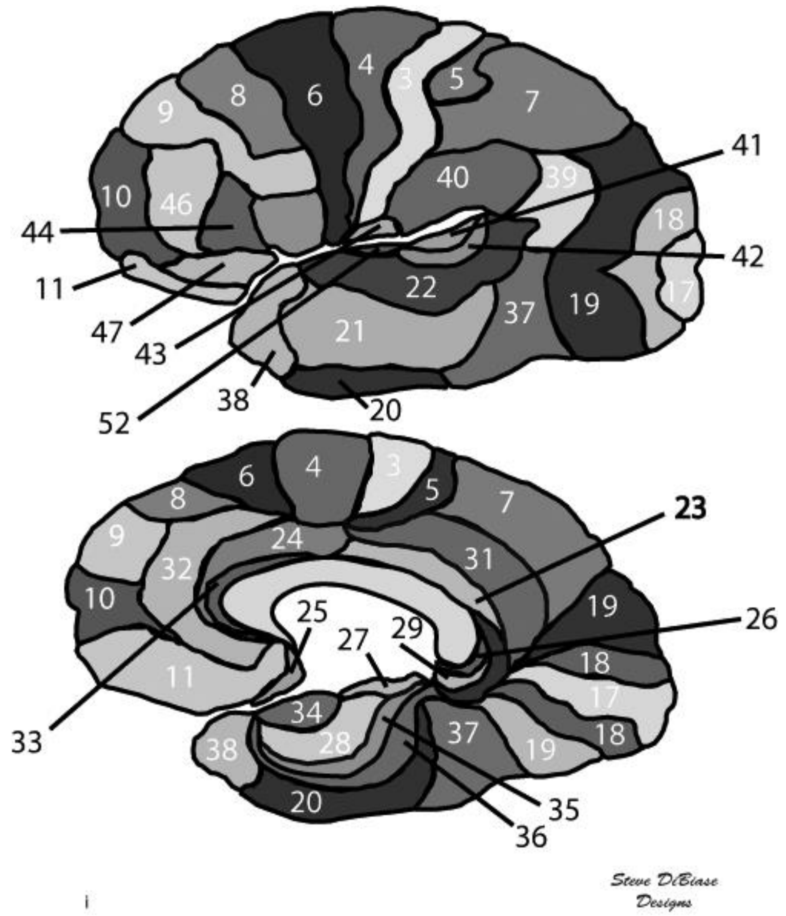

Figure 2-2: Brodmann's cytoarchitecture of the brain; reprinted with permission from NET SMART (www.learnstroke.com), Health Outcomes Institute, LLC.

The subcortex lies directly beneath the cerebral cortex and contains motor and sensory fibres, the basal nuclei, thalami and the lateral ventricles. Afferent sensations travel from the spinal cord through the thalamus and internal capsule and terminate in the cortex, while efferent motor fibres originate in the cortex, travelling through the brain in the opposite direction (9).

The Cerebellum

The cerebellum accounts for 10% of the brain's weight. It is separated from the cerebrum by the tentorium cerebelli, while the vermis separates the cerebellum's left and right hemispheres. Like the cerebrum, the cerebellum consists of an outer grey matter, and an inner white matter (9).

The Brainstem

The brainstem is comprised of 3 structures – the midbrain, pons and medulla oblongata. It also contains ascending sensory pathways, descending motor pathways, cranial nerves III-XII and vital regulatory centers that maintain homeostasis (12).

Blood Supply

While the brain constitutes only 2% of the body's weight, it utilizes approximately 20% of cardiac output (13). As the brain is unable to store oxygen or glucose reserves, it relies on a constant, uninterrupted supply of arterial blood to maintain normal cellular function (13). Autoregulatory mechanisms support continuous flow to the brain, however these processes are energy dependent, and in states where the brain is deprived of oxygen and glucose, autoregulation fails and passive vasorelaxation results (14).

The anterior brain circulation is derived from the common carotid arteries that bifurcate to form the external and internal carotid arteries (ECA and ICA). The ECAs supply blood to the face, neck and scalp, while the ICAs ascend to the brain. At the circle of Willis the ICAs terminate and give rise to the anterior cerebral arteries (ACA), the middle cerebral arteries (MCA) and the posterior communicating arteries (PComA) (13). While the circle is designed to allow some degree of collateral blood flow in the case of a vessel occlusion, only approximately 50% of the population has an anatomically complete circle; hypoplastic or atretic segments are common. (*Figure 3*)

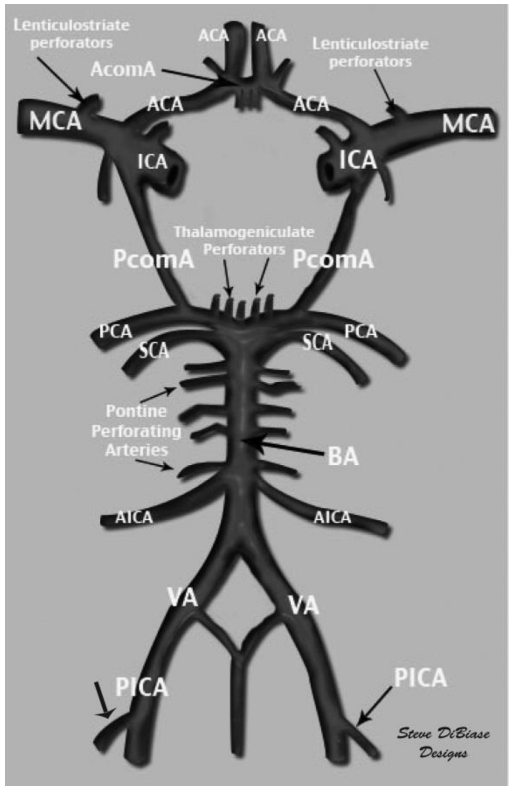

Figure 2-3: Arterial blood supply to the brain; reprinted with permission from NET SMART (www.learnstroke.com), Health Outcomes Institute, LLC.

The MCAs supply the lateral portions of the frontal and parietal lobes, the superior aspects of the temporal lobes, and part of the occipital lobes. Small perforating arteries extend from the main MCA trunks providing blood flow to much of the subcortical region, including the basal ganglia (13). The majority of ischaemic strokes involve the MCAs (15). The two ACAs, joined by a single anterior communicating artery (AComA), supply the rostral and medial surface of the frontal and parietal lobes. The ophthalmic arteries (OA) derive from the ICAs, and supply the optic nerves and eyes. The PcomAs also derive from the ICAs and connect the anterior circulation to the posterior circulation forming the circle (13).

The vertebral arteries (VA) supply the brain's posterior circulation, they enter the cranial vault through the foramen magnum, and fuse at the level of the pons to form the single basilar artery (BA). At its distal tip, the BA divides to form the posterior cerebral arteries (PCA), which provide arterial flow to the temporal and occipital lobes (*Figure 3)*. The VAs and the BA give off numerous arterial branches and perforating arteries to the cerebellum and the brainstem, including the posterior inferior cerebellar arteries (PICA), the anterior inferior cerebellar arteries (AICA), and the superior cerebellar arteries (SCA) (9).

Mechanism of Stroke

Strokes are categorized by aetiology: ischaemic or haemorrhagic. Ischaemic strokes can be further divided into thrombotic (large artery atheroma), cardioembolic, small vessel (lacunar), stroke due unusual cause(s), or cryptogenic (unknown cause) (16). Haemorrhagic strokes are divided into intraparenchymal or subarachnoid haemorrhage. Stroke incidence varies with race. In Western countries ischaemic strokes account for 80% of all presentations, while the incidence of haemorrhagic strokes is much higher in African Americans, Hispanics/Latinos, and most of all Asians who carry the highest incidence of aneurysmal subarachnoid haemorrhage (aSAH) (17).

Transient Ischaemic Attack (TIA)

A TIA is sometimes called a “mini-stroke”, however unlike a stroke, the patient experiences complete resolution of symptoms typically within minutes (18). About 30-50% of patients originally diagnosed with TIA are shown to have small infarcts evident on magnetic resonance imaging (MRI) despite resolution of all neurologic symptoms (19). Occurrence of a TIA is a significant risk factor for future stroke, underlying serious vascular dysfunction. As many as 20% of TIA patients go on to have a stroke within 3 months, more than half of these occurring in the first 48 hours (18). Scoring systems, such as the ABCD2 score, categorize TIA patients into high risk and low risk for a future stroke (*Table 1*). High scores (6-7) carry an 8.1% chance of stroke occurrence within the next 2 days, scores 4-5 have a 4.1% risk, while low scores (0-3) carry only a 1% risk (18). Rapid determination of the TIA mechanism, supported by targeted secondary prevention are key to preventing future stroke.

Table 2-1: ABCD2 score used to grade severity and risk of stroke in patients with transient ischaemic attack.

Clinical criteria		Score
Age	≥ 60 years < 60 years	1 0
Blood Pressure	≥ 140/90 < 140/90	1 0
Clinical features	Unilateral weakness Speech disturbance without weakness Other	2 1 0
Duration	≥ 60 minutes 10-59 minutes < 10 minutes	2 1 0
Diabetes	Yes No	1 0

Ischaemic Stroke

An ischaemic stroke is the result of reduced blood flow either due to an intracranial or extracranial occlusion or stenosis. *Thrombotic stroke*, also referred to as *large artery atheroma*, is associated with risk factors for atherosclerosis, including hypertension (HT), diabetes, smoking, and hypercholesterolemia (20). Endothelial damage and plaque development narrows the artery and changes blood flow dynamics, turbulent flow may further damage the fragile vessel wall (13). Plaque ulceration or rupture results in fibrin and platelet aggregation and thrombus formation, and may cause an artery-to-artery embolism. Depending on the degree of the stenosis, patients may experience a TIA prior to their thrombotic stroke; small clots may temporarily produce symptoms before being auto-lysed by the body, or temporary reductions in blood pressure (BP) may see flow distal to the stenosis reduced to critical levels. Therefore, investigation using vascular imaging is particularly important in the workup.

Lacunar stroke, also called *small vessel* stroke, is a thrombotic stroke that occurs in the small perforator arteries which supply the subcortical regions of the brain and brainstem, and accounts for approximately 25% of all ischaemic strokes (21). The perforating arteries have a very small caliber (0.5mm or less), so the endothelial damage does not have to be extreme for the vessel to completely thrombose (16), and due to their size, vascular imaging will not show an occlusion. While the exact pathogenic mechanism of lacunar strokes is not entirely certain, inflammatory endothelial dysfunction with blood brain barrier failure, significantly damaging vessel walls and stifling arterial flow has gained current acceptance (16). Hypertension is the primary associated risk factor, along with diabetes, hypercholesterolemia and smoking. Despite the size of the tissue damage being small, up to 30% of patients can be left dependent following a lacunar stroke (21).

A *cardioembolic stroke* is caused by emboli that have developed in or traveled through the heart. The most common pathogenic mechanism is atrial fibrillation (AF), which accounts for approximately 20% of all strokes (22). Other mechanisms include: valvular heart disease, left ventricular dyskinesis, acute myocardial infarction, and even venous thromboembolism (VTE) with embolic transfer through an intracardiac right-to-left shunt from atrial septal defect or patent foramen ovale (16, 23). While the use of anticoagulants helps reduce the risk of emboli formation (23), it is not a fail-safe guarantee. As a cardioembolic stroke is not the result of a long-term atherosclerotic process, there is no ability for collateral arterial channel development, therefore such strokes may result in devastating infraction and subsequent disability (22).

Stroke can also be caused by unusual processes such as vessel dissection, hypercoaguable blood, sickle cell disease and vasculitis. However the odds of a stroke occurring from these or other unusual mechanisms is less likely, therefore thrombotic and embolic stroke are generally ruled out in all patients before pursuing other aetiologies. The term *cryptogenic* is used to denote “no identifiable cause for stroke,” but should only be selected when an exhaustive work up has ruled out all other causes (20).

Case study 1 Part A: Julie is a 48 yo divorced woman with 3 grown children, one of whom lives with her in their rental apartment. Julie is overweight with a 10 year history of type II diabetes and hypertension both controlled by medication. Two hours ago after coming back from the local shop Julie’s daughter found her mother sitting in her chair and leaning to one side, unable to speak coherently and weak down the right side of her body. This episode lasted *for at least an hour, but then resolved by the time the ambulance arrived. Her BP taken by ambulance personnel = 150/90, HR 85 regular, T 36.6, RR, 16.*

1. *What is Julie's ABCD2 score?*
2. *What is Julie's risk for a stroke in the next 2 days?*
3. *As the stroke team manager what are the immediate actions that should be taken?*

Haemorrhagic Stroke

Haemorrhagic stroke subtypes include intraparenchymal (IPH) and SAH. Subarachnoid haemorrhage is most commonly aneurysmal (aSAH), but it can also occur secondary to IPH, as blood from the hematoma spreads across the surface of the brain. Following an ischaemic stroke, patients may also develop a haemorrhagic transformation of the infarct that may be asymptomatic or symptomatic. Haemorrhagic transformation results from fragile vessels in the infarct zone leaking blood (24). Exact rates of haemorrhagic transformation are unknown as most cases are asymptomatic. However, in symptomatic haemorrhagic transformation causing clinical deterioration, mortality is increased (24). While anticoagulation and thrombolytic therapy can increase the likelihood of hemorrhagic transformation, the rates of a symptomatic intracerebral haemorrhage (sICH) following thrombolytic therapy remain low, approximately 3-6% worldwide (8, 24-26). The most universally accepted definition of a sICH is, development of a large parenchymal hematoma (type 2) in combination with 4 or more points worsening on the National Institutes of Health Stroke Scale (NIHSS) (25, 26).

Intraparenchymal Haemorrhage (IPH)

An IPH is caused by bleeding into brain tissue as the result of an arterial rupture, and accounts for approximately 10% of stroke cases (17). The most common cause of an IPH is uncontrolled HT (17, 27) (*Figure 5*). The small perforating arteries are the most vulnerable to rupture, as they receive the highest in-flow pressures, therefore hypertensive IPH's are most commonly found in the subcortical regions of the brain (17, 28). Approximately 14-38% of hypertensive IPH's continue to expand within the first 24-hours, with the potential to increase in size between 20-30% (27). Less common causes of IPH include ruptured vascular malformations and aneurysms, bleeding disorders, trauma, vasculitis, alcohol and drug abuse (especially cocaine and methamphetamine) and amyloid angiopathy. Amyloid deposits are associated with dementia in the elderly, and are classically located in the superficial cortical areas of the brain. It is thought that amyloid deposits weaken the arterial layers predisposing them to breaking (28).

Figure 2-4: Left basal ganglia intraparenchymal haemorrhage (IPH); reprinted with permission from NET SMART (www.learnstroke.com), Health Outcomes Institute, LLC.

Damage to brain tissue in an IPH occurs through numerous mechanisms. Initially the space occupying effect of the haematoma within the parenchyma exerts compression forces and raises ICP; a mid-line shift may occur if the haematoma is large. The blood components are toxic to the brain tissue, causing cellular destruction, ischaemia and the breakdown of the blood-brain barrier, thereby initiating secondary injury through vasogenic cerebral oedema. Lastly, tissue distal to the rupture may be deprived of blood flow, creating additional ischaemic brain injury (17, 28). Common locations for an IPH include:

1. *The basal ganglia*: Most common site, resulting from rupture of the lenticulostriate perforators derived from the MCAs;

2. *The thalamus*: The thalamogeniculate perforators derived from the PCAs and PComAs;
3. *The pons*: paramedian pontine perforators derived from the BA;
4. *The cerebellum*: The penetrating branches of the PICA and AICA; and,
5. *The cortical regions of the brain*: usually the result of amyloid angiopathy associated with abnormal penetrating arteries, or occasionally an MCA aneurysm rupture (28).

While a small IPH from a single penetrating vessel may produce mild stroke symptoms, a massive IPH around the vital centers in the brainstem can result in a life-threatening situation (28, 29). A massive IPH is often associated with a severe headache, vomiting, and altered levels of consciousness including coma, pupil alterations and haemodynamic instability, as well as hemisensory and hemimotor changes. IPH's can extend into the subarachnoid space and the ventricular system, creating secondary intraventricular haemorrhage and aSAH (27-29).

Subarachnoid Haemorrhage (SAH)

SAH is caused by bleeding from the large arteries within the subarachnoid space. The most common cause is a ruptured aneurysm, which is more common in middle-aged women, with a mean presentation age of 50 years (30). The exact aetiology of aneurysmal SAH is not entirely understood, but most commonly includes HT causing haemodynamic stress at points of arterial bifurcation, as well as connective tissue disorders, mycotic aneurysms, and genetic familial mechanisms (30, 31). Severe atherosclerosis can also result in fusiform aneurysm development with circumferential breakdown of the entire vessel wall. Aneurysms are most commonly found in the anterior circulation (13, 30). (*Figure 6*)

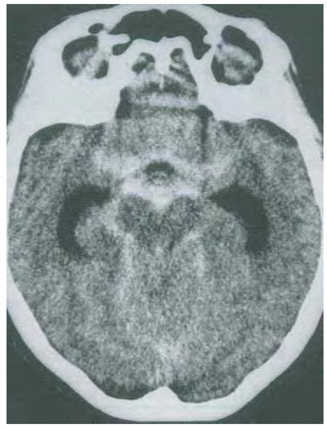

Figure 2-5: Computed tomography (CT) scan of diffuse subarachnoid haemorrhage (SAH) with communicating hydrocephalus (large temporal horns of the lateral ventricles); reprinted with permission from NET SMART (www.learnstroke.com), Health Outcomes Institute, LLC.

Vascular malformations account for only about 1-2% of aSAH's. The most common form is an arteriovenous malformation (AVM). High arterial pressure in the thin walled veins causes weakening of the vessel, increasing the risk for rupture (32, 33). Like aneurysms, AVMs are more likely to be found in the anterior circulation. Approximately 10% of AVM's also have an aneurysm on the feeding artery (32). It is thought that AVM's are congenital, and they usually become symptomatic in the 3rd or 4th decade of life (32, 33).

SAH may present with stroke-like symptoms, as well as altered levels of consciousness, pupil changes and haemodynamic alterations. Most commonly though, they present with a "worst headache of my life" scenario, accompanied by meningeal signs such as neck stiffness, vomiting and photophobia due to blood irritating the meninges (30). Injury in aSAH occurs from several mechanisms, including compression of brain tissue with secondary ischaemic injury and raised ICP, as well as secondary ischaemic stroke resulting from vasospasm and communicating hydrocephalus (30, 34).

Stroke Localization

Stroke locale can be described by the affected lobe/s (e.g. fronto-parietal stroke), or by vascular territory (e.g. MCA stroke). Clinical localization of stroke symptoms is an essential skill for critical care nurses and physicians, enabling observation of stroke progression or resolution.

Additionally, because ischemic strokes are generally not visible on non-contrast computed tomography (NCCT) scan until at least 6-8 hours after symptom onset, clinical localization provides the basis for stroke diagnosis (35).

Cerebral cortex

Frontal Lobes

Major functions of the frontal lobes include voluntary motor function, higher intellectual function and language expression (10). The pre-central gyrus is Brodmann's area 4, (*Figure 2*) also called the motor strip; it extends from the medial longitudinal fissure bilaterally down both hemispheres to the junction of the temporal lobe. The motor strip receives dual vascular supply (*Figure 7*): ACAs supply the medial/superior aspects of the motor strip, while the MCAs supply the lateral regions (10).

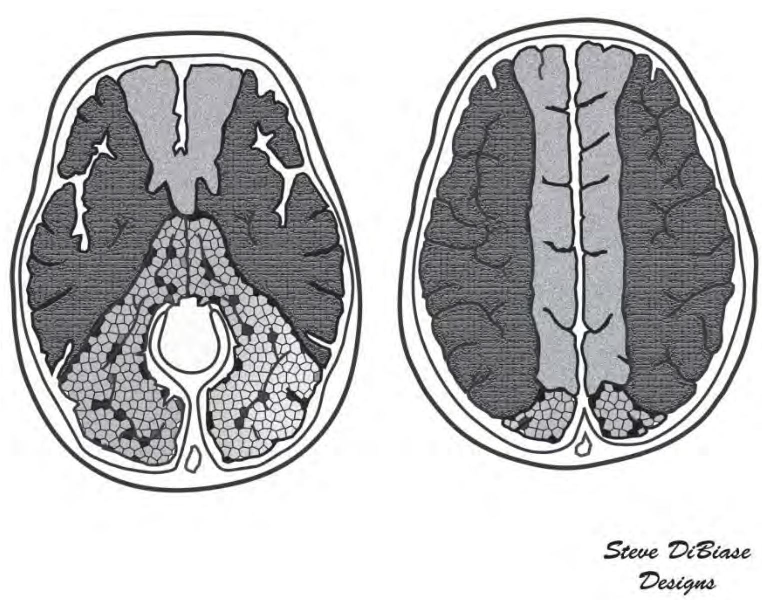

Figure 2-6: Arterial distribution of the cerebral cortex (inferior view-left; superior view right); the dark grey areas represent the middle cerebral artery (MCA) territories bilaterally; the light grey areas represent the anterior cerebral artery (ACA) territories bilaterally; the beaded grey areas reflect the posterior cerebral arterial (PCA) territories bilaterally; reprinted with permission from NET SMART (www.learnstroke.com), Health Outcomes Institute, LLC.

Within the motor strip, the area responsible for the leg movement is within the ACA territory superiorly, while the arms, hands, and face are located laterally in the MCA territory

(10). Consequently, an MCA stroke classically produces weakness in the arm, hand, face, tongue, larynx/pharynx. Distal ICA and proximal MCA occlusions can also affect the leg by stifling flow into the ACA (9). Motor fibres from Brodmann's area 4 travel through the subcortex to the brainstem, where they cross over to the other side in the pyramids of the medulla, producing weakness contralateral to the side of the injury (10, 36).

Brodmann's area 44 (*Figure 2*), also called Broca's area, lies anterior to area 4; damage to this region results in expressive language loss (aphasia). Supplied by the MCA, area 44 most commonly occurs in the left hemisphere, including in left handed people (11). It is important to assess hand dominance in patients who present with a right MCA stroke who also have expressive language loss, since rarely left handed individuals may have area 44 located on the right. Damage to Brodmann's area 44 will cause difficulty with both written and spoken language. Clinical examination must assess word finding capabilities and fluency of language (37). Dysarthria may also be present due to the proximity to Brodmann's area 4 (36).

Brodmann's areas 9, 10 and 11 (*Figure* 2) are supplied by the ACA and lie adjacent to the longitudinal fissure. These cortical areas play a key role in cognition and executive functioning, including orientation, memory, insight, judgment, and arithmetic and abstraction (10, 12). An ACA stroke can result in a patient displaying behavioural changes independent of motor weakness. Changes to cognition may be mistaken for language dysfunction (MCA stroke), therefore thorough clinical assessment and localization is essential (36). (*Table 2*)

Table 2-2: Localization rules for frontal clinical findings; reprinted with permission from NET SMART (www.learnstroke.com), Health Outcomes Institute, LLC.

Clinical Findings (sudden onset)	Possible neurovascular territory
Arm and face weakness	Contralateral MCA
Leg weakness	Contralateral ACA
Arm, face and leg weakness	Contralateral distal ICA (supplying both MCA and ACA) or proximal MCA
Loss of language frequency	MCA (usually left)
Cognitive changes	ACA

Parietal Lobes

The parietal lobes are the primary sensory lobes of the brain. They also receive dual vascular supply from the ACA's and MCA's (*Figure 7*). Sensory information is sent from the periphery through the thalamus to the parietal cortex. The primary sensory strip lies in the post-central gyrus behind the motor strip, and is represented by Brodmann's areas 1, 2 and 3 (*Figure 2*). The sensory strip distribution parallels the motor cortex with the feet, legs and trunk located superiorly in the ACA territory, while the arms, hands and face are found laterally in the MCA territory (11). Like the motor cortex, the sensory strip is found in both hemispheres and when damaged will result in contralateral symptoms. (36).

Brodmann's areas 5 and 7 (*Figure 2*) are supplied by the MCA and are involved in somesthetic association. Assessment involves using double simultaneous stimulation (DSS) to test for neglect or extinction. In DSS testing, patients may be able to detect sensations if they are applied singularly, but may 'neglect' the stroke affected side during simultaneous touch or visual testing (36). The patient may also display difficulty with sensory interpretation, such as stereognosis and graphesthesia, where they are unable to decipher everyday objects by touch alone or determine a number or letter traced on the affected limb (37).

Found in the MCA territory, Wernicke's area (Brodmann's 39 and 40) (*Figure 2*) is responsible for receptive language, and like Broca's area, it is most commonly found in the left hemisphere. This area is also responsible for making language connections with other areas of the brain, such as auditory language in the temporal lobe, memory in the limbic system and expressive language responses in the frontal lobe. A stroke affecting Wernicke's can result in fluent aphasia, where the patient can produce speech but lacks comprehension, so speech may be present but word placement is nonsensical. A large left MCA stroke can affect both language centres, resulting in global aphasia (37).

It is important to note that while isolated parietal lobe damage does not produce motor weakness, a parietal lobe stroke often occurs in association with a frontal lobe stroke due to their shared blood supply, thus motor and sensory changes are often seen together (36) (*Table 3*).

Table 2-3: Localization rules for parietal clinical findings; reprinted with permission from NET SMART (www.learnstroke.com), Health Outcomes Institute, LLC.

Clinical findings (sudden onset)	Possible neurovascular territory
Arm and face numbness (and weakness)	Contralateral MCA
Leg numbness (and weakness)	Contralateral ACA
Arm, face and leg numbness (and weakness)	Contralateral distal ICA or proximal MCA
Loss of receptive language	MCA (usually left)
Sensory neglect	Contralateral MCA

Temporal Lobes

The superior aspects of the temporal lobes are supplied by the MCA's (*Figure 7*) while the posterior and inferior aspects are supplied by the PCA's. The temporal lobes have major functions in auditory reception and olfaction (10). Brodmann's area 41 is the primary auditory reception area (*Figure 2*) present bilaterally to supply the brain with sound impulses from each ear. Area 28 (*Figure 2*) located in the hippocampal gyrus, is the primary olfactory center (10) (*Figure 7*). While temporal lobe damage can result in auditory hallucinations, primary auditory loss is a rare complication, occurring more commonly in a brainstem stroke (12, 36) .

Occipital Lobes

Supplied by the PCA's, the occipital lobes are the most posterior aspect of the cerebral cortex, and are the primary visual lobes. Brodmann's area 17 (the primary visual cortex) and 18 (the visual association cortex) (*Figure 2*) are responsible for receiving and interpreting visual images. (37) (*Figure 7*). Brodmann's area 18, helps the brain map visual images in terms of spatial awareness, orientation and colour. Visual agnosia may result from an occipital stroke, where the patient can see but lacks the ability to interpret or make sense of what they are seeing (36)

Images travel from the eyes, along the optic nerves to the optic chiasm and the optic tract, before being transmitted to the cortex for processing and interpretation. Visual changes can result from damage to any part of this pathway. Monocular vision loss occurs from damage at the level of the retina or optic nerve, whereas binocular defects indicates damage at the chiasm or beyond (36). A homonymous hemianopia is a binocular defect characterized by a loss of vision in one-half of the visual field in both eyes (e.g. left homonymous hemianopia means that vision is lost in the left half of the visual field in both eyes). While a homonymous hemianopia always indicates damage beyond the chiasm, it can result from a large MCA fronto-parietal stroke that damages the visual pathways, as well as from primary occipital cortical damage (38). Clinical assessment will help with stroke localization, as pure visual loss in the absence of other findings occurs in PCA occipital stroke, while the addition of sensorimotor symptoms points to an MCA fronto-parietal stroke. Cortical blindness (double hemianopia) is a rare finding, indicating bilateral PCA strokes. Multiple PCA strokes over time can result in cortical blindness, as can a single severe stroke, such as a top of the BA stroke which reduces flow into both PCA's simultaneously. Diplopia (double vision) is the result of brainstem damage and not occipital lobe damage (11, 36).

Case study 1 Part B: You are about to move Julie for a CT scan when all of a sudden you notice that she is unable to speak and appears to not comprehend you, has complete flaccidity of the right side of her body including face and is staring to the left.

1. *Considering Brodmann's cytoarchitecture of the brain, please describe which areas of the brain have been affected and why?*
2. *What is the likely arterial territory affected by the stroke?*
3. *What is the type of speech abnormality that Julie presents with?*

The Subcortex

Subcortical strokes result from damage to small perforator arteries. A subcortical stroke can be small (lacune, single perforator) or large (multiple perforators), and can be asymptomatic or very physically disabling, depending on the exact locale of the stroke (21). While a subcortical stroke will not result in damage to the primary motor or sensory cortices, sensorimotor changes can be present if the thalamus or afferent sensory/efferent motor tracts are affected. To aid stroke localization, pure cortical symptoms such as neglect, aphasia and apraxia will be absent in a subcortical stroke (11, 36). Strokes within the subcortical grey matter of the basal ganglia can result in extra-pyramidal motor dysfunction, such as rigidity, non-fluid muscle tone, reduced speed of actions, tremors or other involuntary movements (10, 12).

The Cerebellum

The cerebellum is supplied by the VA's, PICA's, BA, AICA's and the SCA's (36). The cerebellum is responsible for fine motor coordination, tone, posture, balance and equilibrium (12). Cerebellar tests include: tandem gait walking, Romberg's test assessing balance and gait stability and ataxia, where the patient is asked to run their heel up and down their opposite shin, and to quickly alternate touching their nose and the examiner's extended index finger while the degree of smooth motor control is assessed (36). Ataxia, dysmetria, dysarthria, dysphagia and unsteady gait are all pathological findings and are usually ipsilateral to a cerebellar lesion. Cerebellar strokes can also present with vertiginous symptoms which need to be distinguished from a peripheral vertigo (39).

While the cerebellum is involved in motor control, a pure cerebellar stroke does not cause motor weakness or alterations in sensation. However, cerebellar stroke often occurs in association with a brainstem stroke due to their shared blood supply. Therefore a clinical presentation of both ataxia or vertiginous symptoms *and* weakness or numbness should raise suspicions of a combined cerebellar and brainstem stroke (36, 39).

The Brainstem

The brainstem shares its vascular supply with the cerebellum. The brainstem contains sensory and motor pathways, cranial nerves (CN) III-XII, and the major control centres of the body (40). Given the spread of cranial nerve distribution throughout the brainstem, stroke symptoms can vary depending on the specific location of the lesion.

The Midbrain

The midbrain houses the visual reflex centre for coordinated head and eye movement in response to visual and auditory stimuli, and cranial nerves III (oculomotor) and IV (trochlear). A midbrain stroke can result in extraocular eye movement (EOM) disorders, diplopia, pupillary dilation, changes to the level of consciousness (LOC) and sensorimotor alterations (12, 36, 40).

The Pons

The pons houses cranial nerves V (trigeminal), VI (abducens), VII (facial) and some of VIII (vestibulocochlear), as well as the apneustic and pneumotaxic respiratory centres (10, 12, 40). A pontine stroke can cause changes to the respiratory pattern, a decreased LOC, sensorimotor changes and EOM disorders. Diplopia can result from a lack of visual fusion caused by damage to the extraocular muscles and nerves, particularly CN's III and VI (12).

The Medulla Oblongata

The medulla is continuous with the spinal cord. Voluntary motor fibres decussate (cross over) in the pyramids of the medulla (40). The medulla houses cranial nerves: VIII (vestibulocochlear), IX (glossopharyngeal), X (vagus), XI (spinal accessory) and XII (hypoglossal). It also contains the cardiac and vasomotor centers, as well as an additional respiratory centre (12, 40). Medullary stroke can cause sensorimotor dysfunction, haemodynamic instability, altered LOC, and speech and swallowing difficulties (36).

The Basilar Artery (BA)

It is important to make special mention of the BA - it supplies the cerebellum and the brainstem and gives off the PCAs, therefore occlusion can produce significant variation in symptoms, including: sensorimotor alterations, vertigo, ataxia, nystagmus, clumsiness, hiccups, shivering, dysarthria, diplopia, cortical blindness (top of the BA), dysphagia, quadraparesis and reduced LOC, including coma and locked-in syndrome (41, 42). A BA stroke is the most frequently misdiagnosed of all ischaemic stroke presentations, often mistaken for a cerebral stroke, peripheral ear disorder, an intracerebral haemorrhage, or primary respiratory disorders (36, 41).

Clinical localization rules that guide stroke differentiation:

1. Patients with hemisensory or hemimotor loss that is extensive (face, arm and leg) and all on the same side, will have a lesion within either the cortex, subcortex or the upper brainstem
2. Patients who present with *bilateral* symptoms, that is, cranial nerve symptoms on the opposite side to sensorimotor changes in the extremities, will have a lesion at the midpoint of the pons or lower
3. Uncommon findings such as auditory loss, vertigo, extra-ocular movement (EOM) disorders, hiccups and shivering are usually associated with a brainstem stroke
4. Any sudden loss of consciousness that is not caused by a haemorrhagic stroke is suspicious for a brainstem (BA) stroke

Stroke Management

The principles guiding acute stroke management aim to optimize patient functional status and reduce disability and death, through rapid identification and diagnosis of stroke, delivery of disability reducing treatments, avoidance of complications, determination of stroke pathogenic mechanism and risk factors, and provision of targeted, individualized secondary prevention strategies. In acute ischaemic stoke, the first priority after emergent diagnosis is arterial recanalization to restore blood flow, whereas in haemorrhagic stroke, the first priority is to prevent haemorrhagic expansion (5, 43).

Hyperacute Stroke Management

Emergency stroke care varies internationally, but most countries offering hyperacute stroke services will have some form of pre-hospital emergency service to assess, stabilize and transport acute stroke patients to hospitals to a Stroke Centre (43). Pre-hospital stroke scales, such as the Los Angeles Pre-hospital Stroke Scale (LAPSS), the Cincinnati Pre-hospital Stroke Scale (CPSS) and the Melbourne Ambulance Stroke Scale (MASS) are often used to assist paramedic diagnosis of stroke. Both MASS and LAPSS trained paramedics have been proven to be highly accurate in diagnosing stroke, and by using pre-hospital stroke protocols, they are instrumental in reducing door-to-treatment times, and increasing the number of patients eligible for reperfusion therapies in the Emergency Department (ED) (44-47).

Not all patients arrive via ambulance, so the triage nurse plays a vital role in recognizing an acute stroke and activating the correct stroke protocols (46, 48, 49). These will vary between facilities, but most stroke centres accept the 3 - 4.5-hour time window for intravenous alteplase (IV t-PA) treatment, while others may use extended hours to incorporate intra-arterial (IA) procedures, including endovascular clot retrieval (ECR) and/or clinical trial enrollment (25, 48, 50). The Emergency Severity Index (ESI) is a common triage prioritization system used in ED's. Acute stroke patients should be allocated a category 2, i.e. they "should not wait to be seen" by a medical provider; however, some stroke patients with altered LOC or respiratory/haemodynamic compromise may be an ESI category 1 meaning they are at "imminent risk for death." Regardless, both category 1 and 2 strokes should be immediately assessed both clinically and radiologically (with urgent brain scans), and all relevant treatments commenced in a high acuity area of the ED (51).

Hyperacute Ischaemic Stroke Management

Thrombolysis treatment with IV t-PA is the gold standard treatment for acute ischaemic stroke, but its use is limited by both time and patient selection parameters (8, 26). IV t-PA is approved by governmental drug regulation agencies for administration at either 3 hours (United States, Canada, Croatia, and Moldova) or 4.5 hours (Europe [excluding above], Asia, South America, South Africa, Israel, and Australia) from symptom onset or the time the patient was last seen normal, although most providers give the medication out to 4.5 hours regardless of governmental regulations (50, 52). Thrombolysis therapy is not without risk, however contemporary rates for systemic bleeding and sICH are quite low (3-6%), even when alteplase is used out to 4.5 hours from symptom onset; this is especially true at Stroke Centres with high alteplase treatment volumes (8, 25). Patient selection should include careful review of neuroimaging to exclude haemorrhagic stroke or structural lesions (tumors, AVMs, aneurysms), and the clinical exam should reveal findings consistent with a neurovascular territory. Most advanced centres do not wait for laboratory blood results before commencing treatment, except in patients with specific histories that indicate potential abnormalities (8, 25, 26, 53). International randomized placebo controlled trials and phase IV effectiveness studies have consistently shown that patients who receive treatment with alteplase have a 30% greater chance of having minimal to no neurological disability by 3 months, with no increased risk of death, making alteplase the most important first step in managing acute ischaemic stroke (25, 26, 54).

Time is brain, and almost 2 million neurons die each minute in a large vessel stroke, while every 15-20 minute reduction in time to treatment gains the patient an extra month of disability-free life and reduces the odds of mortality by 5% (48, 55, 56). Traditional international recommendations have called for IV t-PA to be administrated within 60 minutes of patient arrival to hospital (the “Golden Hour”) (35, 57). However, as the benefit of alteplase treatment is frontloaded, with almost 3 times improved odds for minimal to no disability at 3 months when treatment is commenced within the first hour of stroke onset, many large volume centres are now aiming for a door-to-treatment time of less than 30 minutes to maximise patient outcomes (8, 25, 26, 54). Obviously, treatment within 30-60 minutes is not easily accomplished, yet top programs in Helsinki, Finland and Melbourne, Australia were the first in the world to achieve this goal, with median treatment times well under 30 minutes (58, 59). Strategies to improve door-to-treatment times, including the use of highly educated and specialized acute stroke advanced practice nurses, “Code Stroke” teams, and standing orders for many acute stroke processes, including blood tests and NCCT scans (58, 60-62).

Recommendations to achieve rapid IV t-PA commencement include: immediate stroke team or ED physician assessment, in line with ESI triage Category 2, quickly ascertaining the history; blood work drawn and sent to the lab; vital signs and a 12-lead electrocardiogram obtained (35, 63). The National Institute of Health Stroke Scale (NIHSS) is an internationally used and validated stroke scale, which quantifies stroke disability, ranking stroke symptoms with scores of 0 (no disability) to 42 (severe disability). The NIHSS is considered standard of care in most countries for use by both stroke nurses and physicians, and it should not be substituted for simpler scores such as the Glasgow Coma Scale (GCS) which has no validity in ischaemic stroke (64, 65).

A NCCT scan should be commenced within 25 minutes of the patients' arrival (35), or in the case of a patient with a stable airway, breathing and circulation, the patient may be brought immediately to the imaging suite. Because it is highly sensitive to blood and can be completed rapidly, NCCT is the neuroimaging test of choice allowing the team to quickly rule out haemorrhagic stroke (35, 66). In the hyperacute phase of ischaemic stroke, it is expected that the NCCT will either be normal or have only very subtle early signs of infarction, such as slight blurring of the grey-white matter boundaries, early loss of sulcal effacement, subtle changes to density around the deep white matter or a hyperdense artery sign (5, 35). Additional CT modalities such as a CT angiogram (CTA) and CT perfusion (CTP) are not necessary to make an alteplase decision, but may be useful in the overall determination of stroke mechanism. In particular, CTA will differentiate large versus small artery occlusion which will determine the need for advanced therapies, including ECR; and CTP may offer information that makes the patient eligible for treatment beyond the standard alteplase 4.5 hour window (67, 68). While MRI is more sensitive to early ischaemic changes, it is usually impractical in the management of acute ischaemic stroke due to both unavailability for emergency CT scanning and longer scanning times (35, 52). When NCCT is positive for haemorrhage, CTA can also provide useful information, including diagnosing aneurysms or arteriovenous malformation, as well as documenting ongoing bleeding (27, 30, 69). Following NCCT completion, the scan must be rapidly interpreted; blood tests can be interpreted as they become available, but without any history of anticoagulation, these take on less importance when determining alteplase eligibility.

High volume stroke centres aiming for treatment times of less than 30 minutes cut out many of the above steps, or perform parallel tasks, beginning with calling a "Code Stroke" immediately upon pre-hospital notification, gathering the stroke team to the ED. This means it is the stroke team, not the ED physician performing the initial assessment and taking the history. Haemodynamically stable patients with no other immediate care needs are taken directly from the triage area to the CT scanner. The stroke team reads the patient's CT scan in real-time on the CT console and an immediate treatment decision is made. If the decision is to treat, the drug is drawn up in the CT control room and started while the patient is still on the CT table. The patient can then be reinserted into the CT scanner for completion of a CTA while the alteplase drip is running (58, 61, 62).

Stroke is a severely disabling disease; therefore, the decision to treat with alteplase should not require a written informed consent, much like emergency surgery following trauma or provision of reperfusion therapy in an acute myocardial infarction. However, it is important when possible, to explain the risks and benefits of alteplase treatment to the patient and/or family and to document their assent to treatment. The alteplase dose is weight-based, but unless the hospital bed or ED stretcher is equipped with a scale, it is not practical to weigh the patient; instead, the patient or family are asked to provide a weight estimate, or the stroke team will make a 'best guess' of the patient's weight. Interestingly, lack of measuring weight has not been shown to decrease the safety of alteplase treatment (70). Alteplase is administered at a dose of 0.9mg/kg not to exceed a total dose of 90 mg; 10% of the total dose is given as a bolus, followed by a 60-minute infusion of the remaining 90% of the total dose.

Uncontrolled HT is the most common factor associated with the development of sICH following t-PA. Therefore it is vital that any deviations to the specified BP parameters are acted upon quickly with intravenous antihypertensive agents (35). However, it is important not to lower the BP too far because of the risk of reduced arterial flow through an occlusive lesion that may worsen the ischaemia (35, 71, 72). Many alteplase protocols advise against using non-invasive oscillometric blood pressure (NIBP) cuffs after IV t-PA, advocating instead for the use of manual sphygmomanometers, as there is concern that the degree of mechanical compression caused by an NIBP machine may cause bruising and haematoma development in the arm. However, there are no studies that have documented actual soft tissue injury/bruising occurring from NIBP in alteplase treated patients, so this risk is likely unfounded. Because alteplase alters normal blood coagulation, unnecessary invasive procedures (blood draws, nasoenteric tube or urinary catheter insertion) should be avoided for the first 24 hours post alteplase unless absolutely necessary.

Hyperglycaemia in the acute phase of a stroke has been shown to worsen neurological outcomes, and should be promptly treated with insulin to maintain near normal blood glucose between (4.5-6.0 mmol/L or 80-110mg/dL) (35, 52, 72-74). Hyperthermia is also associated with poorer outcomes, due to increased metabolic demands on an already taxed brain, and temperatures above 37.5°C (99.5°F) should be treated with paracetamol (acetaminophen) per os if the patient has passed a swallow screen or per rectum or intravenously in the case of dysphagia (35, 72, 74, 75). Acute stroke unit patients who had their temperatures and blood sugar levels regularly checked and treated, and who were kept nil orally until safe swallowing were documented, were found to have a 15.7% improvement in 3-month death and dependency rates, demonstrating that good nursing care can positively impact patient outcomes (74).

Up to 22% of patients in the first 24-hours experience neurological deterioration as a result of arterial re-occlusion (76). Therefore, patients should be carefully assessed using the NIHSS, and an urgent NCCT scan should be performed on all patients who have a neurological deterioration (35). Patients who develop a sICH may need reversal of alteplase with cryoprecipitate, however most patients developing sICH do not undergo reversal as the damage is well advanced prior to when initiation would be possible. Patients who experience a vascular re-occlusion may be eligible for ECR (35). In patients with large arterial vessel occlusion (LVO), placing the head of bed (HOB) at zero degrees has been shown to increase blood flow by 20% to ischaemic regions of the brain to stabilize the patient while other potent therapies (alteplase and/or ECR) are commenced (46). The negative HeadPoST study investigated if this practice resulted in improved functional outcomes at 3 months, however the study randomized primarily small vessel (lacunar) strokes, and the selection of a 3 month outcome based on head positioning alone was inappropriate (77). The ZODIAC Stroke study is examining if zero degree positioning can promote stability in hyperacute LVO patients – the only patients ever shown to benefit – using a proximal clinical endpoint appropriate for a head positioning rescue therapy (www.ZODIAC-Stroke.com).

Thrombectomy or ECR has recently demonstrated efficacy in achievement of minimal or no disability at 3 months in patients with a demonstrated large vessel occlusion. Unfortunately, this procedure is not widely available, with few specialist centres offering this service worldwide. Eligible patients should still be treated with IV t-PA, and initiation of ECR must not be delayed by waiting to determine if alteplase treatment was effective. While ECR is generally available for up to 6-8 hours after stroke onset, it has been shown to be most successful when performed as soon as possible after stroke onset. A number of devices are approved for use throughout the world, but only retrievable stents (stentrievers) have shown efficacy at achieving a difference in functional outcome by 3 months (78). Similar to a coronary angiogram, a femoral artery approach with light sedation is usually used, although some patients may require intubation for their own safety during the procedure. Nursing care of the patient having an ECR includes sedation and airway management, weaning and extubation procedures if the patient was intubated, haemodynamic monitoring, neurovascular observation of the distal extremity, and observation for haematoma or bleeding at the femoral site, along with care of intra-arterial sheaths that may be left in post-procedure. Similar to all ischaemic stroke patients, ongoing neurological assessments must be documented using the NIHSS (63).

Hyperacute Haemorrhagic Stroke Management

Like an ischaemic stroke, there are limited hyperacute stroke treatments available for haemorrhagic stroke. Some patients may be appropriate for surgery, but in most instances, treatment is medical management of the symptoms and BP. Not all patients are suitable candidates for neurosurgery; haematoma size (too large and the damage is too extensive, too small and the risks of surgery outweigh the benefits), location (superficial cortical regions), and the patient's pre-morbid health are key criteria. Unfortunately, in most cases, acute surgical management may be lifesaving, but ultimately does not negate the level of permanent disability (27, 79).

In the case of a SAH, endovascular occlusion of aneurysms or AVM's by coil or liquid embolic agent, or surgical clipping may be indicated to reduce the initial size of the structural lesion, permanently occlude it, and prevent re-bleeding (80). If SAH is clinically likely, yet is not apparent on NCCT, it may be necessary for the patient to undergo a lumbar puncture to assess for blood in the CSF and confirm the clinical diagnosis (80).

Close monitoring for signs of ongoing bleeding, development of hydrocephalus and raised ICP are essential for best patient outcomes in a haemorrhagic stroke. Aggressive BP reduction has been proposed as a method to limit haematoma growth, especially in hypertension-induced IPH's, although a phase III clinical trial showed no difference in 3 month outcomes (INTERACT-2); another phase III trial (ATACH-2) was stopped early due to futility (81, 82). Despite this, most stroke specialists agree that some degree of BP control is warranted. Specific BP aims will be determined by local protocols, as will drugs of choice, but intravenous agents that allow good control without causing hypotension or rebound HT are recommended (43). Coagulation status must be determined quickly, and any coagulopathy reversed (29, 83). In particular, warfarin related coagulopathies are associated with significant haematoma expansion and should be urgently treated with vitamin K and cryoprecipitate or prothrombin complex concentrate (29); fresh frozen plasmas is usually discouraged or used as last resort, because of the large volume that would be necessary to reverse coagulopathies. Factor VIIa has also been used, but is expensive, often has limited availability, and has not been shown to improve 3-month outcomes (29, 84). Current trials are looking at other agents that can be used to reverse coagulopathies that may be less expensive and easier to administer, with possibly better outcomes (69).

Hydrocephalus can develop if the ventricles or the arachnoid villa become obstructed, especially as a result of aSAH; this may necessitate the use of a ventricular drain to prevent a dangerous rise in ICP (29). Like any pressure line, a ventricular drain/ICP monitoring system should be leveled and zeroed appropriately, in this instance, to the foramen of Monro (43). Nursing care should include maintaining the patient with the HOB elevated to 30°, aiding venous drainage through proper head positioning and reducing stress including noise and workload. Close observation of the pressure line/drain and monitoring of neurological condition are crucial as catheter blockages are not uncommon and can result in a sudden clinical deterioration (43). While initially designed to be used for ischaemic stroke, the NIHSS is a useful tool in haemorrhagic stroke patients with focal deficits, providing significantly greater information on the patient's clinical status than the GCS which only assesses consciousness (64).

In cases of a massive haemorrhagic stroke where the prognosis is incredibly poor, it may be more appropriate that the patient is considered for a palliative approach rather than be subjected to lengthy and ultimately futile medical investigations and treatments. The patients' wishes (if known) should be taken into account, this needs to be sensitively discussed with the patients' family, ideally in conjunction with a palliative care team (43).

Case study 2 Part A. John is a 65 yo recently retired policeman. He has been bought to the ED by paramedics with his wife present. John is unconscious, BP 195/100, HR 62, T 37.5, RR 20 and labored. John's wife noted that he went to bed after dinner having complained of a headache, when she checked on him 2 hours later he could not be roused and had vomited.

1. *As Johns nurse, what are the immediate care priorities in this hyper acute phase?*
2. *What diagnostic tests might you need to prepare for to receive a rapid and accurate diagnosis of John's condition?*
3. *What medications, if any are likely to order at this stage, why?*

Ongoing Acute Stroke Management

Once the hyperacute phase of stroke management is organized and underway, the focus shifts to the ongoing care required for the remaining duration of the patient's hospital stay. Most of the care initiated in the ED will continue in the acute stroke unit (ASU), including BP, glucose and temperature management. New priorities will also be set for both ischaemic and haemorrhagic stroke, including prevention of complications, discharge planning necessitating the input of the multidisciplinary team, determination of aetiologic mechanism, commencement of secondary prevention targeting the aetiology, and education, all in an attempt to reduce the likelihood that the patient will have a new stroke in the future (43).

To determine aetiology, the patient will undergo numerous investigations. Large vessel imaging (if not already performed in the hyperacute care phase), will be needed to look for stenoses of the major extra- and intracranial arteries in ischaemic stroke, particularly the ICA's, which may require surgical intervention to remove plaque by carotid endartectomy (85). In the case of IPH, vascular imaging is also important to determine mechanism and ongoing bleeding, but this tends to occur in the hyperacute phase so that interventions may be planned. In both ischaemic and haemorrhagic stroke, MRI is often used to measure the final outcome of stroke interventions and aid in determining stroke location and mechanism (86). To detect AF, cardiac monitoring is usually used for at least the first 24 hours, and ongoing monitoring may be ordered as an outpatient if AF is suspected but has not been seen while the patient is in hospital (87). An echocardiogram (transthoracic and/or transoesophogeal) may be ordered to look for underlying cardiac and valvular disease, including a previously undetected right-left shunt associated with atrial septal defect or patent foramen ovale; this is also important in IPH patients because underlying poorly controlled hypertension may have caused ventriculomegaly and left ventricular remodeling. In ischaemic stroke patients with no other clear cause of stroke, additional blood work may be ordered to detect hypercoaguable conditions (88), and in a small number of cases, the cause may never be found.

Similar to the hyperacute care phase, patients need to have regular, serial neurological assessments performed to detect changes in their clinical condition. Deterioration can be the result of a variety of causes, including haematoma expansion in haemorrhagic stroke, haemorrhagic transformation of an ischaemic stroke, vascular re-occlusion, and most commonly evolution of the existing infarction (35). In aSAH, deterioration can also be the result of vasospasm which usually peaks between days 5-7 post rupture, and may produce delayed ischaemic injury causing a secondary ischaemic stroke (30). Vasopspasm is best detected using non-invasive transcranial Doppler (TCD) monitoring. Repeat brain scans should be urgently ordered if deterioration occurs (30, 35).

BP control continues in the acute stroke unit but BP aims may need to be adjusted to maintain flow through existing extracranial or intracranial stenoses, or through spastic arterial segments in aSAH. Intravenous agents initiated while the patient was nil per os can be changed to oral agents, or administered via enteral tubes in patients with dysphagia. It is often necessary to combine multiple antihypertensive agents to achieve adequate control, and each agent should be added slowly and adjusted to effect. Consideration should be given to the mechanism of drug action, taking into account concurrent renal and cardiac disease, and even race, as studies indicate that certain types of antihypertensives may be more effective in different races (e.g. calcium channel blockers may be more effective than ACE-inhibitors in hypertensive black patients due to lower rates of renin-induced hypertension) (35, 43, 89).

Regardless of whether the patient is having an ischaemic or haemorrhagic stroke, blood sugar levels should continue to be carefully monitored and managed in the ASU, ideally maintaining normoglycaemia (between 4.5-6.0mmol/L or 80-100mg/dL), but certainly less than 10mmol/L (180mg/dL). Agents selected should be driven by the degree of glycemic control needed, with patients that present with extremely poor control considered for insulin management (29, 35, 74). It is essential to continue to closely monitor temperature, as hyperthermia is associated with poor neurological outcomes post stroke, additionally a temperature may also herald an infectious process such as an aspiration pneumonia which can worsen mortality rates (35, 72, 74). To reduce the risk of aspiration, the patient should be kept nil per os until they have been properly assessed and cleared for oral intake with either an evidence-based dysphagia screening tool, or formal evaluation by the speech-language pathology team (74, 90). It is important that these assessments are conducted as early as possible in the patient's hospital stay, as even 24 hours without nutrition may negatively impact recovery, especially in elderly patients with premorbid malnutrition (43). Be aware that patients may have already aspirated prior to arrival at hospital, particularly those who were found collapsed as a result of their stroke. Saliva aspiration is possible, even in patients who are nil per os, therefore exquisite pulmonary assessment and care are high priority. Patients should be maintained side-lying and deep breathing and coughing exercises should be encouraged to reduce the risk of chest infection, and nursing assessments should include monitoring for changes to respiratory function, such as respiratory rate, pattern of respirations, breath sounds and gas exchange, as well as pulse oximetry values (43).

Sleep apnea is associated with stroke in 30-70% of cases but it is unclear if the aetiology is from a central or obstructive cause, or a combination of both (91). Patients with suspected sleep apnea should have sleep studies performed so appropriate therapy can be instituted. Sleep apnea can have a significant impact on the ischaemic brain following stroke. Under normal physiological conditions, an apneic period will raise the level of carbon dioxide (CO_2) in the brain, resulting in arterial vasodilation in healthy brain regions, however in ischaemic regions, arteries are already passively maximally dilated (92). Termed “Reversed Robin Hood Syndrome (RRHS)”, vasodilation in healthy regions of the brain ultimately “steals” blood flow away from the already maximally dilated ischaemic brain thus worsening ischaemia in the area affected by stroke (92). Treatment of the sleep apnea with non-invasive modes of ventilation, such as continuous positive airway ventilation (CPAP) or bi-level positive airway pressure (BiPAP) reduces arterial steal maintaining consistent arterial flow rates though the brain (91).

Protocols for patient care after IV t-PA often call for bed rest for the first 12-24 hours to reduce the risk of a major bleed in the event of a fall, and early aggressive mobilization may place patients at risk for worse 3 month outcomes (93). However, once ischaemic and haemorrhagic stroke patients are haemodynamically stable without fluctuating stroke symptoms, progressive mobilization and assessment of physical capabilities by physiotherapists and occupational therapists is essential to minimize complications, such as venous thromboembolism (VTE) development, physical deconditioning, and skin breakdown (35). Even while the patient is in bed, passive range of motion exercises with each positional change can help, and some hospital beds have the capability of placing the patient into a chair-like seated position that can also be beneficial. The development of pressure sores should not occur with good nursing care practices, and their occurrence can significantly impact upon hospital length of stay, health economics, patient comfort and stroke morbidity (94). Vigilant mouth care can prevent complications such as oral candida colonization and the development of candida pneumonia in aspirating patients, a serious complication that will significantly impact length of stay and patient mortality and morbidity rates (94).

The prevention of VTE is complicated, as the use of anticoagulants carries the best evidence, but use in the initial period may cause haemorrhagic expansion in a patient with an IPH (94). To date, there are no large trials that have fully vetted the safety of anticoagulation use in haemorrhagic stroke, but most experts agree that once the haemorrhage has stabilized, use of anticoagulation is probably safe; therefore, most Stroke Centres start anticoagulation after 36-48 hours (29). In ischaemic stroke, anticoagulation for VTE prophylaxis is considered standard of care, and has not been shown to increase the risk of significant haemorrhagic transformation (35, 94, 95). Research has found the use of graduated compression stockings to be ineffective at preventing VTE in patients suffering from stroke, and there is concern that below-knee stockings may increase VTE risk and if improperly sized cause limb ischaemia (95). Sequential compression devices have been shown to reduce VTE risk, but may cause skin breakdown if improperly applied and managed, so good nursing care is important to successful, safe use (35, 95).

The routine use of indwelling catheters to manage urinary incontinence post stroke is not encouraged and bladder training as part of continence programs should begin early in hospitalization (43). In the event that a patient develops urinary retention, a temporary “in-out” catheter should be used, where the catheter is inserted long enough to empty the bladder and then removed (52). Because catheter insertion is an invasive procedure, it should not be performed within the first 24 hours following alteplase administration due to increased bleeding risk. A catheter may be required in patients needing close monitoring of their fluid balance status, such as patients with congestive cardiac or renal failure, or those requiring significant fluid resuscitation (43).

Smoking is a major risk factor for stroke and all patients who smoke should be counseled about smoking associated risks, and the benefits of quitting during their acute stay

(35, 52). This can be reinforced along the recovery journey, especially if they are transitioned to a rehabilitation facility. To increase the likelihood that the patient will quit permanently, the patient's family and significant others should be involved in counseling sessions, so that they may act as support in times of need. While the patient is in hospital, nicotine replacement products should be offered as part of a smoking cessation plan (43).

Nurses play a vital role in providing stroke education to the patient and their family. In the initial phases of hospitalization, the patient and their family may not retain much information, requiring it to be repeated more than once. Topics that will need to be covered include:

- The stroke process (ischaemic and/or haemorrhagic)
- Stroke symptoms and warning signs
- Stroke treatments
- Prevention of complications
- Hospital discharge planning
- Stroke recovery, including the rehabilitation process
- Personal risk factors and modification strategies
- When and how to call for an ambulance (35, 43, 52)

Patients with an ischaemic stroke may require some additional management strategies to improve their outcomes and reduce their future stroke risks. In the event of a large MCA or cerebellar stroke, malignant cerebral oedema can develop which may significantly increase ICP, causing tissue compression, herniation, coma and subsequently death. As the brain atrophies with age creating space within the cranial vault, older patients with significant atrophy at baseline are at lower risk for development of malignant oedema, however, in young patients even small amounts of oedema can be life threatening. Craniectomy procedures, which remove a large section of the skull, prevent brain compression, by allowing the infarcted brain to swell outside the boundaries of the skull (96, 97). Craniectomy is considered a lifesaving procedure, but is not necessarily a disability reducing procedure (96). The removed skull segment is stored in a bone bank or sewn into a pouch that is created inside the abdomen, and the patient is placed on helmet precautions. Approximately 3 months after stroke, the bone segment is replaced. In craniectomy for cerebellar stroke, the skull segment is not replaced post-operatively (43).

In ischaemic stroke, prophylactic secondary prevention is generally a triple therapy of an antiplatelet, (or anticoagulant in the setting of atrial fibrillation [AF]), antihypertensive agents, and a statin (35, 98). Options for antiplatelet agents include aspirin, clopidogrel or aspirin-extended release dipyridamole (98-100). When prescribing an antiplatelet agent, clinicians should consider whether the patient is anti-platelet "naive" or if there has been an antiplatelet failure, that is, the stroke occurred while the patient was already on an antiplatelet. Other considerations include if the patient has a history of migraines, cardiac disease or a cardiac stent. Concomitant medications, including drugs like COX-2 selective non-steroidal anti-inflammatories and protein pump inhibitors should also be taken into account, due to potential interactions or risk of gastrointestinal bleeding (43). It is well established that anticoagulation is beneficial for stroke prevention in patients with AF (101, 102). In an attempt to objectively gauge the risk of stroke, scores such as the $CHADS_2$ or CHA_2DS_2-VASc may be used (103, 104). Until recently, warfarin was the only long-term oral anticoagulant available for use, but with the recent release of direct oral anticoagulants (DOACs) onto the market, patients now have more options. Benefits of the DOACs are a static dose regime that may improve patient compliance, and no need for regular blood testing. Currently, only one DOAC agent, Dabigatran, has a direct reversal agent available and due to their half-lives, DOACs are generally considered an exclusion criteria for thrombolytic therapy if taken within 12-24 hours of stroke onset, unless clotting tests can show sub-therapeutic levels. Each DOAC has a different safety profile which needs to be carefully considered before prescribing (105-107). Both ischaemic and haemorrhagic stroke patients benefit from BP control. Over the course of a hospital admission BP should be progressively lowered using generally at least two if not more antihypertensive agents. Patients should be followed after discharge to ensure that they achieve their BP control targets (5).

Aggressive early blood pressure reduction is not recommended and may place patients at risk for deterioration (17). Regardless of cholesterol levels, high dose statins have been found to reduce the risk of stroke, TIA and cardiovascular events (98, 108-110).

Patients who present with a SAH commonly develop vasospasm, which can restrict arterial flow to the point of causing a secondary ischaemic stroke. Treatment has traditionally included use of “triple H” therapy (hypertension, hypervolaemia and haemodilution), however very little evidence supports hypervolaemia and haemodilution, and only small studies have shown hypertension to be efficacious (111). Other vasospasm treatments include IA angioplasty and IA calcium channel blocker administration with verapamil or nicardipine, although 3 month outcome data showing efficacy are lacking to support these practices (112). An external ventricular drain (EVD) may be inserted for CSF diversion and intracranial monitoring in patients with higher Hunt and Hess grade aSAH. EVD CSF drainage should be carefully monitored. It is imperative that the EVD system be maintained as a closed sterile system to prevent infection and minimize development of ventriculitis. Once CSF drainage has become stable, the system can be clamped and the patient monitored for increased ICP; when ICP is found to be stable, the patient can have the EVD removed. However, at times some patients with EVD need to progress to long-term shunt placement. Nimodipine is considered standard of care to increase brain tissue thresholds/tolerance of ischaemia developing from vasospasm, but the drug does nothing to reduce vasospasm itself. Following aSAH, myocardial stunning can occur, but is often time limited and fully reversible; however, when it occurs, it can significantly challenge the ability to perfuse through spastic arterial segments due to concurrent vasospasm (113). Use of inotropic therapies while paying cautious attention to myocardial oxygen demand/consumption can enhance heart function, but requires cautious management to prevent heart failure (43).

Case Study 2 Part B: John returns from the endovascular suite having undergone coiling of a ruptured aneurysm. He has a puncture wound in the right groin where femoral arterial access was obtained. He is intubated, ventilated and is slowly regaining consciousness. A EVD with ICP monitoring is in place as well as a central line and peripheral IV. His vital signs are BP 140/70, HR 80, T 38.2, ICP = 12 mmHg.

1. *Develop a care plan for John's initial first day in ICU coil embolization.*
2. *Describe when John's risk for vasospasm will be maximal, and how he will be monitored for this complication.*
3. *What advice and information will you provide to John's wife on admission to ICU?*

Case Study 1 Part C: Julie has received an emergency endovascular clot removal.

1. *Develop a care plan for Julie to ensure an event-free recovery.*
2. *What education and advice will you provide to Julie and her daughter on discharge?*

Conclusion

In summary, stroke is a global medical emergency and prompt recognition and aggressive treatment at specialist stroke centres is essential to reducing neurological disability and mortality rates. In the case of ischaemic stroke, practitioners must adopt a philosophy of "finding reasons to treat" with intravenous alteplase whenever possible, because it remains the only widely available medicinal therapy proven to reduce disability at no increased risk of death. Intra-arterial therapies are now shown to improve 3-month outcome in large artery ischemic stroke, but this technology is not available at most centres throughout the world, making alteplase treatment even more important. Unfortunately, haemorrhagic stroke remains a troubling disease with few treatment options, carrying high rates of disability and death. The ED, neuroimaging departments, and stroke team play a vital role in hyperacute stroke care, as earlier treatment significantly improves patient outcome and the likelihood of returning to premorbid levels of functioning. Once in the stroke unit, the nursing, medical and multidisciplinary teams are the first line of defense against neurological deterioration and stroke associated complications. Stroke care in the 21st century is truly a team effort and the future is primed for more innovative stroke research, including world class nursing research to further reduce the burden of this crippling disease.

Questions (correct answers follow):

1. The lobe of the brain primarily concerned with tactile sensory function, spatial orientation and receptive language is the:
    a. Frontal lobe
    b. Temporal lobe
    c. Occipital lobe
    d. Parietal lobe
2. The anterior brain circulation is derived from the common carotid arteries that bifurcate to form which two arteries?
    a. external and internal carotid arteries (ECA and ICA)
    b. anterior and posterior communicating arteries (AcomA and PcomA)
    c. Vertebral and basilar arteries
    d. Frontal lobe arteries, left and right hemisphere
3. The Middle Cerebral Arteries (MCAs) supply the following area of the brain:
    a. Broca's expressive language area
    b. Visual cortex
    c. Medullary respiratory center
    d. Cognition area
4. The circle of Willis is designed to allow some degree of collateral blood flow in the case of a vessel occlusion, however only approximately X % of the population has an anatomically complete circle. X = ?
    a. 20%
    b. 35%
    c. 50%

d. 65%

5. TIA is an important warning sign for acute ischaemic stroke. What percent of patients experiencing TIA will go on to have a stroke within 3 months?

   a. 20%

   b. 35%

   c. 50%

   d. 65%

6. Cardioembolic stroke, is caused by emboli that have developed in or traveled through the heart. The most common pathogenic mechanism is:

   a. atrial fibrillation

   b. valvular heart disease,

   c. left ventricular dyskinesis,

   d. acute myocardial infarction

7. Common findings in patients with lacunar stroke include which of the following?

   a. Atrial fibrillation

   b. Cerebral venous thrombosis

   c. Alzheimer's dementia

   d. Diabetes

8. Your patient is experiencing a right cerebellar stroke. Which of the following is the likely presentation?

   a. Loss of language fluency

   b. Cognitive dysfunction

   c. Right sided limb ataxia

   d. Diplopia

9. Because it is highly sensitive to blood and can be completed rapidly, which of the following neuroimaging tests allows the team to quickly rule out haemorrhagic stroke?
    a. Magnet Resonance Imaging
    b. Non Contrast Computed Tomography
    c. Transcranial Doppler
    d. PET scan
10. Which of the following is <u>not</u> commonly included as part of the education program for a patient following a TIA or ischemic stroke:
    a. Stroke symptoms and warning signs
    b. Prevention of complications
    c. Surgical treatment and post-operative management
    d. Personal risk factors and modification strategies
    e. When and how to call for an ambulance

Answers

1. D
2. A
3. A
4. C
5. A
6. A
7. D
8. C

9. B

10. C

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Chapter 3

Shock and Multiple Organ Dysfunction Syndrome

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Learning Outcomes

After completing this e-chapter you will be able to:

1. Identify characteristics that are common to all types of shock.
2. Classify the various etiologies of shock as belonging to one of the following categories: hypovolemic, cardiogenic, distributive, or obstructive shock.
3. Explain the cellular, metabolic, and hemodynamic alterations occurring in shock and relate them to alterations in oxygen delivery.
4. Understand the pathophysiological basis for the progression of shock from the initial stage through the compensatory, progressive, and refractory stages.
5. Explain the etiology, pathophysiology, and clinical manifestations of cardiogenic shock.
6. Attribute the treatment strategies for cardiogenic, hypovolemic, anaphylactic, neurogenic, and septic shock to the underlying pathophysiology involved.
7. Explain the etiology, pathophysiology, and the clinical manifestations of mild, moderate, and severe hypovolemic shock.
8. Relate the etiology, pathophysiology, prevention, and the clinical manifestations of anaphylactic shock to the immune mechanisms involved.

9. Explain the etiology, pathophysiology, and clinical manifestations of neurogenic shock and differentiate neurogenic from spinal shock.
10. Differentiate the criteria for systemic inflammatory response syndrome, sepsis, severe sepsis, and septic shock.
11. Explain how microorganisms activate host defense systems, how those host defense systems function in the pathophysiology of septic states, and how they produce the clinical manifestations in septic states.
12. Describe the criteria for multiple organ dysfunction syndrome, the pathophysiological mechanisms responsible for organ dysfunction, and the clinical indicators of dysfunction of various organs.

Chapter Overview

Shock is a clinical condition that can result from several causes including injury, trauma, infection and severe bleeding, and represents an imbalance between oxygen supply and demand. Shock is characterized by hypoxia and inadequate cellular function that can lead to organ system failure and death. There are several distinct types of shock including cardiogenic, hypovolemic, anaphylactic, neurogenic, and septic shock. Despite having different etiologies, all of the shock states have similar manifestations of inadequate peripheral tissue perfusion, impaired cellular function, and impaired organ perfusion.

Although compensatory mechanisms, including the sympathetic nervous system and neurohormonal responses, attempt to maintain cardiac output and perfusion, hypoxic injury and cellular and organ damage can occur. Recognizing the signs of shock and instituting treatment measures can help reestablish perfusion and prevent further detrimental effects. This e-chapter presents the pathophysiology of shock, common signs and symptoms, and management strategies to promote best outcomes for patients in shock.

Introduction to the Chapter Cases

Case Study One: *A 69 year old female is brought to the emergency room by a neighbor who reports that she found the patient in an incoherent state in her apartment after the neighbor had noticed that the patient had not checked her mail for 3 days. The patient is currently awake and responsive, but is lethargic. She is Russian and speaks little English.*

Current vital signs: Bp: 88/50mmHg Hr: 125bpm Temp: 97.4 (^oC) Respirations: 34bpm

Initial physical exam reveals a thin white female, ill in appearance. The skin is cool to touch and the skin and mucous membrane color are pale. Lungs have bibasilar rales to auscultation posteriorly. Abdomen is soft with hyperactive bowel sounds. She has no jugular vein distention. Slight pedal edema is present, capillary refill is sluggish. The EKG reveals sinus tachycardia. A Foley's catheter was inserted for 60 cc dark yellow urine return.

Details about her past medical history are unavailable. An IV is started and lab work is drawn.

A Russian translator arrives in the ER and begins interpretation. The patient relates that she is very weak and dizzy but denies pain. She states that she has had a "flu bug" for the past week, has not kept much food down and has been having diarrhea.

Case Study Two: *A 75 year old male with a 6 year history of hypertension and a 30 pack per year cigarette history was admitted to the ICU with a diagnosis of cirrhosis secondary to biliary obstruction. He underwent an exploratory laparatomy and cholecystectomy 3 days ago. Postoperatively, he was relatively stable, experiencing an episode of hypotension 12 hours postoperatively which was corrected by fluid administration. He remains intubated at TV 800 FIO2 40%, IMV 8 Peep +5 and attempts at weaning have been delayed due to periodic hypoxemia.*

He currently has an arterial line, CVP, T-tube drain and foley catheter. He is alert and oriented, moving in bed with little assistance. Physical exam reveals that his skin is pale pink, warm to touch, lungs have a few bibasilar rales, 1+ pedal edema is present bilaterally. His *abdomen is nondistended, no active bowel sounds. His 5 inch midline abdominal wound requires tid dressing changes and is approximated with retention sutures. His hourly urine output has decreased from 100 to 50 cc/hr. He is currently receiving total parenteral nutrition via the CVP.*

Current vital signs: Temp: 101.0(^{o}C) HR: 122bpm, Sinus tachycardia, Respirations: 34bpm, BP: 90/60 mm Hg. He required several liters of lactated ringers and was started on low dose norepinephrine, a vasocontrictive agent to increase his blood pressure and improve perfusion.

Categories of Shock

Shock results when oxygen balance is disturbed and demand exceeds supply and is the body's response to physiologic injury, trauma, or infection (Medline Plus Health Information, 2015). The major types of shock include cardiogenic, hypovolemic, anaphylactic, neurogenic, and septic shock (Pasman & Corden, 2015). Shock is commonly classified into 4 main categories based on cardiovascular characteristics including hypovolemic, cardiogenic, distributive, which occurs when peripheral vascular dilation results in a decrease in systemic vascular resistance (which includes anaphylactic and septic shock) and obstructive shock, in which the flow of blood is obstructed which impedes blood flow, occurs with tension pneumothorax, cardiac tamponade, constrictive pericarditis, or massive pulmonary embolism (Zimmerman, 2012).

Alterations in Hemodynamics, Oxygen Delivery, and Cell Metabolism in Shock

Shock is a clinical syndrome that results from inadequate oxygenation and tissue perfusion (Medline Plus Health Information, 2015; Pasman & Corden, 2015; Wedro, 2014; Zimmerman, 2012). Shock occurs when the blood supply to the organs, tissues, and cells of the body is decreased. Inadequate blood supply impairs cellular function. When shock occurs, systemic hypotension, acidosis, and impairment of vital organ functioning result (Pasman & Corden, 2015). An imbalance between the delivery and the uptake of oxygen leads to cellular dysfunction. Regardless of the specific type and cause of shock, the end result is impaired tissue perfusion, which leads to inadequate oxygenation to the cell, causing cellular damage and eventually, hypoperfusion to organs (Wedro, 2014).Clinical signs include hypotension, tachycardia, tachypnea, cool skin, altered level of consciousness, and oliguria (Wedro, 2014). Additional clinical changes relate to the hemodynamic profiles of shock as outlined in Table 1.

Table 3-1. Hemodynamic Profiles of Shock

Type of Shock	**Heart Rate**	**Cardiac Output**	**Ventricular Filling Pressures**	**Systemic Vascular Resistance**	**Pulse Pressure**	**S_vO_2**
Cardiogenic	↑	↓	↑	↑	↓	↓
Hypovolemic	↑	↓	↓	↑	↓	↓
Distributive	↑	↑ or N[a]	↓ or N[b]	↓	↑	↑ or N[a]
Obstructive	↑	↓	↑	↑	↓	↓

S_vO_2, mixed venous oxyhemoglobin saturation; N, normal
[a] May be decreased prior to or early in resuscitation
[b] Left ventricular filling pressures may be normal or low in massive pulmonary embolism
Adapted from Zimmerman JL (Zimmerman, 2012).

In shock, oxygen delivery to the mitochondria of the cell is decreased, leading to stalled energy production and failure of ion pumps (Na^+, K^+, and Ca^+). As a result, sodium accumulates within the cell, changing the osmotic gradient and causing cellular swelling (Walshe & D'Amore, 2008; Zimmerman, 2012).

Tissue hypoperfusion results in cellular hypoxia. At the cellular level, the body switches to metabolism that doesn’t require oxygen (anaerobic metabolism), which is insufficient to maintain cellular energy needs (Walshe & D'Amore, 2008; Zimmerman, 2012). Anaerobic glycolysis results, with depletion of adenosine triphosphate (ATP) and intracellular energy reserves (Pasman & Corden, 2015; Walshe & D'Amore, 2008; Zimmerman, 2012). Energy that is required for cellular processes is stored in the phosphate bonds of the ATP molecule, and the breakdown of ATP results in the release of energy. With cellular hypoxia, the normal process of ATP breakdown is altered, resulting in increased hydrogen ion concentration (Pasman & Corden, 2015). Anaerobic glycolysis also causes accumulation of lactic acid, resulting in intracellular acidosis.

A brief review of oxygen delivery can help explain the effects of altered tissue perfusion and impaired oxygen delivery in shock. Oxygen delivery (DO_2) is defined as the amount of oxygen delivered to the tissues of the body per minute. DO_2 is dependent upon the cardiac output (CO), or the amount of blood pumped per minute, and the arterial oxygen content of that blood (CaO_2) (Pasman & Corden, 2015). Oxygen delivery is defined by the following equation: DO_2 (mL O_2/min) = CaO_2 (mL O_2/L blood) X CO (L/min). The CaO_2 is dependent upon how much oxygen-carrying capacity is available in terms of hemoglobin (Hb) content as well as by how much oxygen the patient's hemoglobin contains, defined as the arterial oxygen saturation (SaO_2) (Xiushui & Lenneman, 2014). The CaO_2 is defined by the following formula[2]: CaO_2 = Hb (g/100 mL) X SaO_2 X 1.34 mL O_2/g.

A state of clinical shock may exist when CaO_2 is impaired either by hypoxia, which decreases SaO_2, or by anemia, which reduces the amount of hemoglobin (Hb) and hence reduces the body's total oxygen-carrying capacity (Pasman & Corden, 2015). Often, this is why patients in shock are given increased oxygenation, many times through intubation and mechanical ventilation. In addition, blood transfusions can be used to increase the oxygen-carrying capacity of the blood.

Cardiac output is the amount of blood pumped each minute, and is determined by the patient's stroke volume (SV) and heart rate (HR). The cardiac output is defined by the following formula: CO = HR (beats/min) $\times$ SV (mL/beat) (Pasman & Corden, 2015).

SV is dependent upon the ventricular end-diastolic filling volume (commonly referred to as ventricular preload), myocardial contractility, and the afterload (Pasman & Corden, 2015). These factors can be impaired in clinical shock states and impact the cardiac output (Pasman & Corden, 2015).

These principals are used to provide treatment measures to the patient in shock. Often, intravenous fluids are administered in order to increase preload, vasopressors are used to decrease afterload, and inotropes are given to improve contractility.

Stages of Shock

There are several distinct stages of shock. These include the initial, compensatory, progressive, and refractory stages of shock (Pasman & Corden, 2015). In the initial stage of shock the cardiac output is decreased, leading to decreased blood supply. Clinical evidence of decreased cardiac output includes cool clammy skin, decreased urinary output, altered level of consciousness, cyanosis, pallor, and hypotension (Pasman & Corden, 2015).

When tissue perfusion is impaired, changes in the normal functioning of the cell occur. As the blood supply to cells decreases, cells switch from aerobic to anaerobic metabolism as a source of energy. Anaerobic metabolism produces minimal energy and leads to a buildup of lactic acid, which is detrimental to the functioning of a cell. Lactic acidemia develops, causing more cellular damage as the body is unable to buffer the increased levels of acid. The degree of lactic acidosis can be determined by monitoring serum lactate levels. Normal serum lactate levels are less than 1 mmol/L (Pasman & Corden, 2015; Wedro, 2014). Lactic acidosis is associated with high levels of serum lactate (greater than 5 mmol/L). In some patients with shock, neither the arterial pH nor bicarbonate may reflect the presence of lactic acidosis. Therefore, the most accurate assessment of the severity of lactic acidosis is the serum lactate level (Walshe & D'Amore, 2008; Zimmerman, 2012). However, the arterial pH and serum bicarbonate might not indicate acidosis in the presence of lactic acidosis as factors such as the degree of hyperlactatemia, the buffering capacity of the body, and conditions such as tachypnea and alkalosis may affect pH levels simultaneously.

In Case Study One, the patient presented to the emergency room with signs of the initial stage of shock as she had tachycardia and hypotension as well as pale skin, demonstrating clinical evidence of decreased cardiac output.

In the compensatory stage of shock, the body’s homeostatic mechanisms attempt to improve tissue perfusion. The compensatory mechanisms are mediated by the sympathetic nervous system (SNS) and consist of neural, hormonal, and chemical responses. Neurohormonal responses attempt to maintain cardiac output in shock. The neurohormonal responses include catecholamine release, causing increased contractility and rennin release by the kidneys which cause the formation of angiotensin I, which is then converted to angiotensin II that causes vasoconstriction, shunting blood to vital organs. Aldosterone is released, causing water conservation. Capillary hydrostatic pressure decreases and shifts fluid to the intravascular space. Antidiuretic hormone release causes conservation of sodium and water leading to decreased urine output. Additionally, release of epinephrine and norepinephrine by the sympathetic nervous system results in increased heart rate (HR) (Pasman & Corden, 2015; Wedro, 2014).

These neurohormonal compensatory mechanisms are triggered in shock to help maintain arterial blood pressure despite a fall in cardiac output (Pasman & Corden, 2015; Walshe & D'Amore, 2008).

Progressive stage of shock: As shock progresses, these compensatory mechanisms are not able to sustain adequate perfusion to tissues and impaired oxygen delivery results. A decreased cardiac output results in impaired oxygenation that causes hypoxic injury to the cells. Metabolic acidosis with severe electrolyte imbalance and respiratory acidosis with hypoxemia can occur. Under anaerobic metabolism, toxic metabolites can accumulate, including lactic acid (Gunnerson & Harvey, 2014) The acid-base status of the arterial blood (pH) is normally between 7.35 and 7.45 (Gunnerson & Harvey, 2014; Walshe & D'Amore, 2008).The blood pH decreases when lactic acid production increases (termed lactic acidosis). Profound acidosis (a pH less than 7.0) results in altered cellular functioning and cellular damage (Gunnerson & Harvey, 2014).

In Case Study Two, the patient has signs of progressive shock as he has episodes of hypotension, sustained tachycardia, tachypnea and impaired oxygenation requiring continued mechanical ventilation. In addition, his urine output has decreased, demonstrating decreased tissue perfusion. Although lab test results are pending, he most likely has a developing state of acidosis.

Refractory shock: In refractory shock, systemic hypoperfusion causes multiple organ damage. At this stage of shock, end-organ damage and cellular necrosis occur as shock becomes unresponsive to treatment. Ultimately, death occurs from impaired tissue perfusion.

CHECK YOUR PROGRESS: Assess your understanding of key points from the previous sections.

- Inadequate tissue perfusion resulting in impaired cellular oxygenation is characteristic of all shock states.
- If shock is not treated or does not respond to treatment it progresses through the following stages: initial, compensatory, progressive, and irreversible.
- Classic manifestations of shock include hypotension, tachycardia, tachypnea, decreased level of consciousness, cool skin, and oliguria.
- As a result of decreased oxygen delivery to cells in shock states, metabolism switches from aerobic with adequate amounts of ATP produced, to anaerobic metabolism in which there is an inadequate amount of ATP produced to support cell functions.

1. Clinical signs of shock include all but which of the following?

    A. Tachycardia

    B. Tachypnea

    C. Oliguria

    D. Hypertension

Answer: D: Clinical signs include hypotension, tachycardia, tachypnea, cool skin, altered level of consciousness, and oliguria

2. What factors influence the cardiac output?

    A. Heart rate and stroke volume

B. Heart rate and rhythm

C. Intravascular volume and contractility of the heart

D. Contractility of the heart and stroke volume

Answer: A. The cardiac output is defined by the following formula: CO = HR (beats/min) × SV

3. Multiple organ damage can occur in which type of shock?

A. Initial

B. Compensatory

C. Progressive

D. Refractory

Answer: D. In refractory shock, systemic hypoperfusion causes multiple organ damage.

Cardiogenic Shock

Cardiogenic shock results when the heart no longer functions as an effective pump, often because of acute myocardial infarction (MI). Other causes include pulmonary edema, cardiomyopathies, dysrhythmias, pericardial tamponade, or valvular regurgitation (Medline Plus Health Information, 2015; Pasman & Corden, 2015). The estimated incidence of cardiogenic shock in hospitalized patients is 5-10% of patients (Medline Plus Health Information, 2015; Pasman & Corden, 2015). In cardiogenic shock, forward blood flow is inadequate due to cardiac pump failure and loss of functional myocardium (ischemia, cardiomyopathy), a mechanical or structural defect (valvular failure, septal defect) or arrhythmias (Zimmerman, 2012). Cardiogenic shock results in decreased cardiac output, altered oxygen delivery, and reduced tissue perfusion.

Specifically, cardiogenic shock is defined as a decrease in cardiac output along with evidence of tissue hypoxia in the presence of adequate blood volume (Medline Plus Health

Information, 2015; Pasman & Corden, 2015). In cardiogenic shock; the heart is unable to effectively contract, leading to ineffective emptying of blood. Right or left ventricular dysfunction can result because of diminished or ineffective contractility. Cardiogenic shock is often characterized by both systolic and diastolic myocardial dysfunction. Inadequate tissue perfusion results from myocardial dysfunction, which leads to cellular hypoxia and ischemia, the end results of shock (Gorman, Calhoun, & Carassco, 2008; Xiushui & Lenneman, 2014).

Clinical Manifestations of Cardiogenic Shock

Clinical signs and symptoms of cardiogenic shock include pale, cool clammy skin, hypotension, tachycardia, oliguria, low cardiac output and cardiac index (less than 2.2 L/minute/m^2), distended neck veins, pulmonary edema and S3 gallop (Medline Plus Health Information, 2015; Pasman & Corden, 2015; Wedro, 2014; Zimmerman, 2012). Cardiogenic shock is diagnosed based on clinical signs and symptoms as well as specific hemodynamic criteria that indicate inadequate cardiac functioning. These include sustained hypotension (SBP 30 mm Hg below baseline for at least 30 minutes) and reduced cardiac index , (less than 2.2 L/minute/m^2) with pulmonary artery occlusion pressure (PAOP) (more than 15 mm Hg) (Medline Plus Health Information, 2015). The cardiac index is a more specific vasodynamic parameter that is related to the body surface area. It is calculated by dividing the cardiac output by the body surface area. The PAOP, also termed pulmonary capillary wedge pressure, provides an indirect measure of the left atrial pressure.

Linking Treatment to Pathophysiology of Cardiogenic Shock

In cardiogenic shock, the myocardial dysfunction is difficult to treat because the underlying cellular damage is often irreversible (Gorman et al., 2008; Xiushui & Lenneman, 2014). Treatment goals for cardiogenic shock include increasing contractility, decreasing oxygen demands, increasing myocardial oxygen supply and increasing cardiac output. However, these goals are difficult to achieve, as interventions to increase CO tend to increase myocardial oxygen demands (TS Ahrens, D Prentice, & RM Kleinpell, 2008a; Kar, Basra, Shar, & Loyolka, 2012). The management of cardiogenic shock is aimed at optimizing myocardial function.

Common treatments for cardiogenic shock include supplemental oxygen or endotrachael intubation and mechanical ventilation and hemodynamic support. The initial approach should include fluid resuscitation only if pulmonary edema is not present (Pasman & Corden, 2015; Wedro, 2014; Zimmerman, 2012). Other indicated aspects of treatment can include diuretic therapy to decrease preload and pulmonary congestion; medications, such as intravenous inotropes (e.g., amrinone or dobutamine) to increase the force of contraction,; vasodilator medications such as nitroglycerin or nitroprusside to decrease left ventricular afterload; or the use of vasopressors such as norepinephrine when hypotension remains refractory. Catecholamine infusions such as epinephrine must be carefully titrated in patients with cardiogenic shock to maximize coronary perfusion pressure with the least possible increase in myocardial O_2 demand. Vasopressin, a hormone, has been used with a good response for refractory vasodilatory shock when administered as an intravenous infusion to promote vasoconstriction (TS Ahrens et al., 2008a; Gorman et al., 2008).

Mechanical support devices such as the intra-aortic balloon pump (IABP) can be used to augment coronary artery perfusion and systolic ejection. The IABP is inserted through the femoral artery and positioned in the descending thoracic aorta. It inflates during diastole to improve blood flow to the heart by supplying the coronary arteries with freshly oxygenated blood (TS Ahrens et al., 2008a; Gorman et al., 2008). The balloon then deflates at the end of diastole just prior to ventricular systole (contraction of the left ventricle) to decrease left ventricular afterload (resistance to ejection) to improve cardiac output. The IABP is used for temporary support for patients in cardiogenic shock until either myocardial function improves or surgical intervention can be performed. There are two major complications associated with the use of the IABP: compromised circulation to the leg inferior to the insertion site and balloon rupture. Monitoring of perfusion including pulses, temperature and appearance of the leg below the insertion site is therefore important.

Other assist devices, known as a ventricular assist device, whether percutaneous or surgically inserted, decreases the heart’s workload and increases cardiac output to restore adequate systemic perfusion pressure while allowing time to address the underlying cause of myocardial pump failure (Kar et al., 2012). Other indicated treatment may include reperfusion interventions such as percutaneous transluminal angioplasty or coronary artery bypass surgery. These interventions reestablish perfusion to improve ventricular function after myocardial infarction. The use of reperfusion measures in patients with cardiogenic shock after myocardial infarction has increased survival rates (TS Ahrens et al., 2008a; Kar et al., 2012).

Hypovolemic Shock

Hypovolemic shock is considered the most common form of shock (Kolecki & Menchhoff, 2014). Hypovolemic shock results from loss of blood, from loss of plasma volume of greater than 20% of the circulating volume, or from profound dehydration (Medline Plus Health Information, 2015). Commonly, hypovolemic shock is due to rapid blood loss (Kolecki & Menchhoff, 2014). Other causes of hypovolemic shock include massive gastrointestinal losses, capillary leak, and tissue third spacing, which results in leakage of fluid out of the intravascular space into the interstitial tissues, which can occur in such conditions as pancreatitis, bowel obstruction, and ascites (TS Ahrens, D Prentice, & RM Kleinpell, 2008b; Kolecki & Menchhoff, 2014).

The clinical signs of hypovolemic shock include pale, cool clammy skin, systolic blood pressure 30 mmHg less than baseline, tachycardia, oliguria, and decreased level of consciousness (TS Ahrens et al., 2008b; Kolecki & Menchhoff, 2014). There is wide variation in the clinical symptoms depending upon the amount of volume loss, the rate of loss, and the underlying illness or injury causing the loss (Kolecki & Menchhoff, 2014). With blood volume loss, the hemoglobin and hematocrit will be reduced. Hypovolemia results in shock caused by decreased blood volume, leading to decreased cellular oxygen supply and impaired tissue perfusion (TS Ahrens et al., 2008b; Kolecki & Menchhoff, 2014). As outlined in Table 2, the symptoms of hypovolemic shock are similar to cardiogenic shock with low blood pressure, tachycardia, low urine output, cool clammy skin, weak pulse and altered level of consciousness. The two shock states are differentiated in that cardiogenic shock is characterized by low oxygenation and high pulmonary artery occlusion pressures and often pulmonary vascular congestion.

Table 3-2: Clinical Manifestations of Shock

Clinical Manifestations in Common	**Hypovolemic Shock**	**Cardiogenic Shock**	**Septic Shock**	**Anaphylactic Shock**
Blood pressure	Low	low	low	low
Heart rate	tachycardia	tachycardia	tachycardia	Tachycardia
Urine Output	low (< 0.5 ml/Kg/hr)	low	Low	Low
Level of consciousness	Altered	altered	altered	altered
Skin	Cool, clammy	Cool, clammy	warm	warm
Pulse quality	Weak	weak	weak early strong later	weak
Differentiating Clinical Manifestations				
PaO_2	Normal	Low	low	normal or low
SaO_2	Normal	Low	low	normal or low
Cyanosis	Absent	May be present	absent	absent
a/A ratio	Normal	low	low	low
PAOP	low (<10)	high (> 18)	normal or low	normal or low
Orthopnea	Minimal	present	possible	present
Crackles	Minimal	present	possible	possible
Dependent edema	Absent	present	absent	absent

Clinical Manifestations in Common	**Hypovolemic Shock**	**Cardiogenic Shock**		
Blood pressure	Low	low		
Heart rate	tachycardia	tachycardia		
Urine Output	low (< 0.5 ml/Kg/hr)	low		
Level of consciousness	Altered	altered		
Skin	Cool, clammy	Cool, clammy		
Pulse quality	Weak	weak		
Differentiating Clinical Manifestations				
PaO_2	Normal	low		
SaO_2	Normal	low		
Cyanosis	Absent	May be present		
a/A ratio	Normal	low		
PAOP	low (<10)	high (> 18)		
Orthopnea	Minimal	present		
Crackles	Minimal	present		
Dependent edema	Absent	present		

Adapted with permission, Ahrens et al 2008

Stages of Hypovolemic Shock

There are several distinct stages of hypovolemic shock (see **Table 3**). In the initial stage where approximately 15% (750 ml) volume is lost, compensatory mechanisms maintain cardiac output and the patient is asymptomatic (Kolecki & Menchhoff, 2014). In the second or compensatory stage, 15-30% (750-1500 ml) of volume is lost and the cardiac output falls, resulting in compensatory increase in heart rate and respiratory rate, low urine output, and altered level of consciousness (Kolecki & Menchhoff, 2014). Hypoxemia develops as perfusion to tissues is reduced as a result of the decreased cardiac output. Sympathetic nervous system compensatory mechanisms are activated with resulting vasoconstriction. However, if volume loss continues the third or progressive stage develops in which 30% to 40% (1500 to 2000ml) volume loss occurs and impaired tissue perfusion develops as compensatory mechanisms become overwhelmed (Kolecki & Menchhoff, 2014). Arrhythmias can develop and cause myocardial ischemia and metabolic acidosis and respiratory distress can occur. In the fourth or refractory stage, over 40% (more than 2000 ml) volume loss occurs which is immediately life-threatening. Severe tachycardia, hypotension and organ failure can occur and cardiac arrest may ensue. (TS Ahrens et al., 2008b; Kolecki & Menchhoff, 2014).

Table 3-3: Stages of Hypovolemic Shock

Mild (less than 20% blood volume loss)	Moderate (20 to 40%) blood volume loss	Severe (over 40% blood volume loss)
Cool extremities Increased capillary refill time Diaphoresis Anxiety	Same as mild plus: Tachycardia Tachypnea Oliguria Orthostatic Changes	Same as moderate plus: Hemodynamic instability Marked tachycardia Hypotension Mental status deterioration

Adapted from Harrison's Online Shock. Available at: www.harrisonsonline.com. (May 4, 2013).

Pathophysiology of Hypovolemic Shock

In hypovolemic shock, venous return to the heart (preload) decreases, resulting in decreased cardiac output (Kolecki & Menchhoff, 2014). Compensatory mechanisms respond by increasing heart rate, systemic vascular resistance (SVR), cardiac output, and tissue perfusion owing to catecholamine release (TS Ahrens et al., 2008b; Kolecki & Menchhoff, 2014). Blood volume is increased in several ways, including through neurohormonal mechanisms including the renin-angiotension-aldosterone system that promotes conservation of sodium and water and a shifting of the interstitial fluid into the vasculature in response to the decreased circulating volume. Additionally, the liver and spleen release stored red blood cells and plasma. With continued blood loss, the compensatory mechanisms are unable to maintain perfusion to the tissues and organs, and the end result of shock can result: profound acidosis, altered cellular functioning, and cellular damage (Kolecki & Menchhoff, 2014).

Linking Pathophysiology to the Treatment of Hypovolemic Shock

The treatment goals for hypovolemic shock are to treat the underlying cause, control additional fluid loss, and replace fluid losses (TS Ahrens et al., 2008b; Kolecki & Menchhoff, 2014). Treatment is aimed at reestablishing normal blood pressure, pulse and organ perfusion (Zimmerman, 2012). Volume expanders including crystalloid solutions (e.g., lactated Ringer's solution, normal saline) and colloids (e.g., albumin, hetastarch [Hespan]) are used for fluid resuscitation of patients with hypovolemic shock. Crystalloids are effective at expanding intravascular volume and interstitial fluid (Kolecki & Menchhoff, 2014) Lactated Ringer's solution and normal saline are the two most commonly used isotonic solutions due to the osmolality needed to restore intravascular volume (Kolecki & Menchhoff, 2014). Volume resuscitation with large amounts of normal saline can result in hyperchloremic metabolic acidosis (Zimmerman, 2012). The advantage of using lactated Ringer's solution is that it is metabolized by the liver and kidneys to generate bicarbonate, which provides a buffer against the lactic acid generated by tissue hypoperfusion, thereby promoting normal pH balance

(Kolecki & Menchhoff, 2014). Colloids expand the intravascular space by pulling fluid from the interstitial spaces (Kolecki & Menchhoff, 2014). Although colloids are more effective than crystalloids at increasing intravascular fluid, data suggest an increased incidence of complications and risk of death with the use of colloids, particularly albumin (Kolecki & Menchhoff, 2014).

Blood and blood products are used for patients who are hemodynamically unstable, for patients with greater than 1500 cc blood loss, and patients with ongoing uncontrolled sources of bleeding (TS Ahrens et al., 2008b; Kolecki & Menchhoff, 2014). Transfusion of blood and blood products are usually indicated for a hematocrit less than 28% (Kolecki & Menchhoff, 2014). Whole blood is used to replace large blood loss, while packed red blood cells (PRBCs) are used to replace moderate blood loss (Kolecki & Menchhoff, 2014). Platelets are administered when platelet levels are decreased (thrombocytopenia), which occurs in hemorrhage. Fresh frozen plasma (FFP) is used to correct plasma deficits and restore osmotic pressure (Kolecki & Menchhoff, 2014).

Type-O PRBCs are used for initial resuscitation in emergent situations, until cross-matched blood is available (Kolecki & Menchhoff, 2014). In the presence of coagulopathy, hypothermia, or when PRBC transfusion exceeds six units, platelets and FFP should be administered (Kolecki & Menchhoff, 2014). With massive hemorrhage, in which the volume of blood lost equals the patient's total blood volume, a 70-kg adult may require 10 units of PRBCs in 24 hours (Kolecki & Menchhoff, 2014). New artificial red blood cells that are more like RBCs are being developed (Kar et al., 2012). Red blood cell (RBC) substitutes, often referred to as hemoglobin-based O_2 carriers (HBOCs), consist of extracted hemoglobin from lysed RBCs (Kolecki & Menchhoff, 2014). Most RBC substitutes have a hemoglobin concentration of 10-15%, compared to a typical hemoglobin concentration of PRBCs of 20-25 g/dl (Kar et al., 2012). RBC substitute solutions are typically hypertonic colloids and expand blood volume more than the volume of the infused solution (Kolecki & Menchhoff, 2014).

Other aspects of treatment include determining the cause of blood or volume loss and preventing further volume loss (Kar et al., 2012). Vasopressor medications such as phenylephrine, and dobutamine may be required to increase blood pressure and cardiac output, and should be used only as a temporizing measure while fluid resuscitation is ongoing or when hypotension persists despite adequate volume resuscitation (Zimmerman, 2012). Vasopressors should not be given without adequate fluid replacement because they can cause cardiac decompensation and hemodynamic deterioration, especially in patients with ischemic heart disease (TS Ahrens et al., 2008b; Kolecki & Menchhoff, 2014). Cardiac output and oxygen supply are dependent on adequate intravascular volume and cardiac function, therefore adequate fluid replacement is required to ensure adequate tissue perfusion when administering vasopressors as these agents can cause vasoconstriction. Other interventions may include insertion of a urinary catheter to monitor urine output and hemodynamic monitoring to evaluate cardiac output and metabolic consumption (SVO_2). A central venous catheter may be inserted to monitor central venous pressure.

In Case Study One, the patient presented to the emergency room with signs of shock including altered vital signs with a low blood pressure of 88/50 mm Hg, an elevated heart rate of 125 bpm with sinus tachycardia and an elevated respiratory rate of 34bpm. Her physical exam revealed pale skin and sluggish capillary refill, indicating vasoconstriction to the skin. A foley catheter insertion resulted in 60 cc of dark yellow urine, indicating possibly dehydration. She had no jugular venous distention, which if present, can be a sign of cardiogenic shock.

The patient reported that she was weak and dizzy and had a “flu bug” for the past week with diarrhea. Although lab work was pending, the possible cause of her beginning shock state was dehydration or blood loss with diarrhea. A diagnosis of hypovolemic shock was made with a low hemoglobin and hematocrit and Helicobacter pyloric guiac positive stool (FOBT) confirmed the GI bleeding. A nasogastric tube was inserted with bright red blood return and the patient was taken for endoscopic treatment of a gastrointestinal bleed which was corrected, the patient stabilized and was eventually discharged home.

Anaphylactic Shock

Anaphylactic shock results from an allergic reaction that causes systemic release of IgE (antibody formed as part of immune response) and causes mast cell activation and histamine release (Balentine, 2014; Medline Plus Health Information, 2014). Anaphylaxis affects up to 15% of the U.S. population (Medline Plus Health Information, 2014; Stern, 1997) It is estimated that a total of 3.29 million to 40.9 million individuals are at risk of anaphylaxis (Medline Plus Health Information, 2014; Stern, 1997). Many substances known as allergens can cause anaphylaxis. Allergens may include foods, food additives, drugs, and insect-stings. Insect stings present the greatest number of cases of anaphylaxis (American Association of Allergy Asthma and Immunology, 2015; Stern, 1997) (see Table 4). Routes of entry for an allergen can include injection, ingestion, inhalation, and skin absorption. Clinical signs of anaphylaxis include generalized pruritis, respiratory distress, syncope, and apprehension (see Table 5) (American Association of Allergy Asthma and Immunology, 2015; Stern, 1997). The signs and symptoms of anaphylaxis can appear within several minutes of exposure to the antigen. The severity of the reaction is directly related to the onset of symptoms, with early signs appearing with a severe reaction. Occasionally, biphasic reactions occur in which symptoms recur several hours after the initial reaction. Anaphylaxis is a life-threatening hypersensitivity reaction that can develop rapidly (within seconds) or occur as a delayed reaction (12 or more hours after initial exposure) (American Association of Allergy Asthma and Immunology, 2015; Stern, 1997).

Table 3-4: Common Anaphylaxis Allergens

Foods	**Food Additives**	**Medications**	**Other**
Eggs	Monosodium Glutamate	Antibiotics	latex
Peanut butter	Autolized Yeast	Aspirin	Exercise
Fish	Natural Flavorings	Contrast Dye	Insect venom
Shellfish	Yeast Extract	Blood products	Animal hair
Milk	Food coloring	Vaccines	Dust
Cheese		Narcotics	Pollen
Tomatoes		Local anesthetics	
Chocolate			
Nuts and seeds			

Table 3-5: Clinical Signs and Symptoms of Anaphylaxis

Generalized Signs & Symptoms	**Life-threatening Signs & Symptoms**
Itching (any part of the body)	Respiratory distress/stridor
Swelling (of any body parts)	Bronchospasm
Red, watery eyes	Laryngeal edema
Nausea, vomiting, diarrhea	Shock
Stomach cramps	
Change of voice	
Coughing	
Wheezing	
Difficulty swallowing	
Sense of doom	
Dizziness	

Adapted from American Academy of Allergy, Asthma and Immunology
http://www.aaaai.org/members/academy_statements/position_statements/ps34.asp

Pathophysiology of Anaphylaxis

Anaphylaxis, caused by an antibody-antigen response, results in an extensive immune and inflammatory response (Balentine, 2014; Medline Plus Health Information, 2014; Stern, 1997). Anaphylactic shock results from an allergic reaction that causes release of immunoglobulin E (IgE), an antibody that is formed as part of the immune response. Leukocytes, including mast cells, basophils, and eosinophils, release mediators such as histamine, prostaglandins, kinins, and complement that cause vasodilation, increased vascular permeability, hypotension, brochoconstriction, and coronary vasoconstriction (American Association of Allergy Asthma and Immunology, 2015; Stern, 1997). The result is peripheral pooling of blood, tissue edema, airway constriction, and myocardial depression. A state of relative hypovolemia occurs, with altered tissue perfusion and impaired cellular metabolism. If untreated, anaphylaxis results in a shock state and can lead to cardiac, renal, pulmonary, and multisystem organ failure (American Association of Allergy Asthma and Immunology, 2015; Stern, 1997). Death may result from cardiovascular or respiratory distress.

Linking Pathophysiology to the Treatment of Anaphylactic Shock

The treatment goals for anaphylactic shock include the “ABC’s” (airway, breathing, and circulation) of emergency care, along with volume expansion (American Association of Allergy

Asthma and Immunology, 2015; Balentine, 2014; Medline Plus Health Information, 2014; Stern, 1997). Hypotension should be managed with intravenous fluids to promote intravascular volume expansion. Colloid solutions (e.g., 5% albumin, 6% hetastarch) better facilitate volume expansion than crystalloid solutions (e.g., lactated Ringer's solution, 5% dextrose in normal saline). Vasoconstrictor agents such as norepinephrine (Levophed), phenylephrine (Neo-Synephrine), and dopamine HCL (Intropin) may be administered to reverse the effects of severe vasodilation and myocardial depression (American Association of Allergy Asthma and Immunology, 2015; Balentine, 2014; Medline Plus Health Information, 2014; Stern, 1997). Epinephrine is a first-line drug administered to patients with anaphylaxis to promote vasoconstriction and further inhibit mediator release. The standard dose of epinephrine is 1:1000, 0.3 ml given subcutaneously(American Association of Allergy Asthma and Immunology, 2015; Balentine, 2014; Medline Plus Health Information, 2014; Stern, 1997). Antihistamines, such as diphenhydramine (Benadryl) are useful as second-line drug therapy to block the histamine response and stop the inflammatory reaction. Antihistamines should not be administered without epinephrine (American Association of Allergy Asthma and Immunology, 2015; Balentine, 2014; Medline Plus Health Information, 2014; Stern, 1997). Additional treatment measures include Aminophylline and inhaled beta 2 agonists to reverse Bronchospasm and corticosteroids to help stabilize capillary membranes and prevent a delayed reaction (American Association of Allergy Asthma and Immunology, 2015; Balentine, 2014; Medline Plus Health Information, 2014; Stern, 1997).

Prevention of anaphylactic shock through identification of patients at risk and careful monitoring of patient response to drugs, blood products, and blood are important components of nursing care (American Association of Allergy Asthma and Immunology, 2015; Balentine, 2014; Medline Plus Health Information, 2014; Stern, 1997). Important measures include obtaining a complete allergy history and identifying potential allergens. Patients experiencing an episode of anaphylaxis should be instructed to avoid the allergen. Teaching about the importance of seeking prompt medical attention when symptoms of anaphylaxis occur is an important part of patient education (Balentine, 2014; Medline Plus Health Information, 2014; Stern, 1997). Early identification and prompt medical treatment are essential in preventing a life-threatening reaction. The American Academy of Allergy and Immunology stresses that education of the lay and professional public is important to promote the prompt administration of measures such as administration of epinephrine for the emergency treatment of anaphylaxis (Stern, 1997).

Neurogenic Shock

Neurogenic shock results from loss of peripheral sympathetic vasomotor tone. Neurogenic shock is commonly seen in trauma and results from a change in systemic vascular resistance, mediated by a neurologic injury (e.g., head injury or high thoracic or cervical spinal cord injury) (Chin, 2014). Neurogenic shock is considered the rarest form of shock (Chin, 2014; Guly, Bouamra, Lecky, Trauma, & Research, 2008). Neurogenic shock, sometimes called vasogenic shock, results from the disruption of autonomic nervous system control over vasoconstriction (Chin, 2014). After spinal cord injury, neurogenic shock can occur immediately after injury or can exhibit a delayed response for up to weeks or months after the initial injury (Chin, 2014). Although the terms are sometimes used interchangeably, neurogenic shock is distinguished from spinal shock, which refers to an acute, transient neurologic syndrome of sensorimotor dysfunction that develops with spinal cord injury at any level (American Association of Allergy Asthma and Immunology, 2015). Neurogenic shock is a hemodynamic syndrome associated with upper thoracic and cervical spinal cord injury and is characterized by bradycardia and decreased systemic vascular resistance. The two patterns may or may not occur concurrently (Chin, 2014). Neurogenic shock is suggested by a pattern of decreased heart rate, blood pressure, and systemic vascular resistance (Guly et al., 2008) The classic signs of shock may not be present in neurogenic shock because of alteration in sympathetic tone (Chin, 2014). As a result, bradycardia is commonly seen and the skin is warm, dry, and pink, rather than cool; and pale—at least below the level of spinal cord injury (Chin, 2014; Guly et al., 2008).

Pathophysiology of Neurogenic Shock

In neurogenic shock, sympathetic nervous system deregulation occurs. As vasomotor tone is lost, systemic arteriolar resistance decreases profoundly and venous capacitance increases, resulting in decreased afterload and preload and subsequent massive vasodilation and decreases in cardiac output (Chin, 2014). Unopposed vagal tone results in significant bradycardia.

The loss of normal sympathetic tone also results in an inability to shunt blood from the periphery to the core, and heat loss through the skin becomes excessive, resulting in hypothermia (Chin, 2014). Decreased tissue perfusion results primarily from arterial hypotension caused by a reduction in systemic vascular resistance (Chin, 2014). In addition, a reduction in effective circulating plasma volume often occurs because of a decrease in venous tone that leads to vasodilation and a resultant decrease in blood pressure (Chin, 2014). A decrease in cardiac output leads to decreased cellular oxygen supply and impaired cellular metabolism. The clinical signs and symptoms of neurogenic shock include hypotension and pale, cool, clammy skin with warm extremities above the level of injury. Bradycardia and decreased level of consciousness can also be present (Chin, 2014; Guly et al., 2008).

Linking Pathophysiology to the Treatment of Neurogenic Shock

The treatment of neurogenic shock includes the ABCs of emergency care. Fluid resuscitation is given with caution, as the blood volume is sufficient but blood distribution is altered (Chin, 2014). The administration of a large volume of IV fluids to increase central venous return may cause heart failure. The Trendelenburg position can be used temporarily to increase the blood pressure. Insertion of a Foley catheter may be required, as bladder function may be lost. Atropine may be administered to block dominant vagal effects that cause bradycardia (Chin, 2014). Vasoconstrictive intravenous agents may be used to increase blood pressure that is resistant to fluid replacement (Chin, 2014). Positive inotropic agents such as dopamine and dobutamine at lower dosages (1-5 mcg/kg/min) can enhance cardiac output, increase perfusion pressure, and improve renal hemodynamics (Chin, 2014). However, vasopressors are used with caution, as vasoconstriction may decrease spinal cord blood flow, which can ultimately influence the extent of secondary cord injury. In rare cases, a pacemaker may be required for refractory bradyarrhythmias (Chin, 2014).

Septic Shock

Sepsis and **septic shock** are common, pathophysiologically complex, clinical conditions that are associated with high morbidity, mortality, and cost of care (Mayr et al 2014). Sepsis occurs in response to infection and results in sepsis related organ system dysfunction and/or circulatory shock, resulting in high morbidity and mortality rates for hospitalized patients (Cohen et al 2015). While estimates show trends toward decreasing in hospital and case fatality rates, the incidence of sepsis cases is increasing at a larger rate. These developments have resulted in a large number of sepsis related fatalities and a larger number of survivors who require post hospital care and/or are unable to resume their prior occupation (Kempker and Martin 2016). Although a growing number of potential biomarkers have been studied to improve the capability of diagnosing sepsis, most lack specificity (McLean 2015; Faix 2013; Kibe et al 2011; Marshall et al 2009; Rivers et al 2013; Gibot et al 2012). Clinicians are currently using clinical criteria for sepsis surveillance and identification based on prior consensus definitions (Levy et al 2003). However these definitions have limitations. Recently, a 3rd Sepsis Definitions Conference published new definitions and clinical criteria for the diagnosis of sepsis and septic shock (Singer et al 2016).

Epidemiology of Sepsis

In the United States, sepsis is the most common cause of death in noncardiac intensive care units and the 10th leading cause of death overall. The incidence of sepsis is increasing because of a number of factors (see Table 6). The rise in the number of cases of sepsis is expected to continue because of the number of elderly patients in health care facilities; an increased number of patients with compromised immune status, chronic illness, or malnutrition; an increased number of patients having invasive and surgical procedures; and an increased number of resistant microorganisms, among other factors (Balk, 2000; Vincent et al., 2002).

Table 6: Risk Factors for Sepsis

- Extremes of age: under age 1 and over age 65 years
- Surgical/invasive procedures
- Malnutrition
- Broad-spectrum antibiotics
- Chronic illness
- Diabetes mellitus
- Chronic renal failure
- Hepatitis
- Increased number of patients with compromised immune status
- Acquired immunodeficiency syndrome
- Increased use of cytotoxic and immunosuppressant agents
- Alcoholism
- Malignancy
- Increased number of transplant recipients and transplantation procedures
- Increased number of resistant microorganisms
- Increased number of elderly patients
- Increased awareness and sensitivity for the diagnosis

Adapted from Balk RA. Severe sepsis and septic shock. Definitions, epidemiology, and clinical manifestations. Critical Care Clinics 2000; 16:179-192.

In Case Study Two, the patient had several risk factors for infection including increased age, and status post a surgical procedure with a midline incision requiring frequent dressing changes. In addition, he had several invasive lines including an arterial line and central venous catheter, a foley catheter and a t-tube drain, all of which can predispose to infection risk. Special Consideration for the Aged: As the patient was age 76, a consideration with respect to the presentation of sepsis is that due to altered immune system response, he may not have demonstrated a classic presentation with an elevated temperature. Often, the aged patient with *developing sepsis presents with a normal temperature. Additionally, aged patients may present with altered level of consciousness or confusion*

While early recognition of sepsis is important and influences survival, the clinical signs of sepsis can be difficult to identify. Signs of sepsis include changes in vital signs (decreased blood pressure, increased heart rate, increased respiratory rate, and increased temperature), along with signs of altered perfusion to vital organs (e.g., decreasing urine output from the development of acute renal failure). Septic shock is characterized by hemodynamic changes including high cardiac output and decreased peripheral resistance due to dilation of systemic resistance vessels and dysfunction of one or several organs (Alves-Filho, de Freitas, Spiller, Souto, & Cunha, 2008; Salomao et al., 2008). Often, patients with sepsis exhibit signs of the systemic inflammatory response or SIRS criteria: alteration in temperature (most often elevation), elevated heart rate (more than 90 beats/minute), elevated respiratory rate (more than 20 breaths/minute or a PCO_2 less than 32 mm Hg), and an altered white blood cell count (less than 12,000 cells/mm^3, less than 4000 cells/mm^3, or more than 10% immature (band) forms) (Balk, 2000). Several terms specifically define the progression from infection to severe sepsis to septic shock and are outlined in Table 7.

Table 7: Sepsis Terms and Definitions

Infection: Microbial phenomenon characterized by an inflammatory response to the presence of microorganisms or the invasion of normally sterile host tissue by those organisms

Bacteremia: The presence of viable bacteria in the blood

Sepsis: Life-threatening organ dysfunction caused by a dysregulated host response to infection

Septic shock: A subset of sepsis in which circulatory, cellular, and metabolic alterations are associated with a higher mortality rate than sepsis alone

Hypotension: A systolic blood pressure of <90 mm Hg or a reduction of >40 mm Hg from baseline in the absence of other causes for hypotension.

Multiple organ dysfunction syndrome: Presence of altered organ function in an acutely ill patient such that homeostasis cannot be maintained without intervention.

(Singer et al., 2016; Rhodes et al., 2017)

Pathophysiology of Sepsis

The pathophysiology of sepsis is complex and is associated with three integrated responses: activation of inflammation, activation of coagulation mediators, and procoagulant factors and inhibition of fibrinolysis (C. J. Fernandes, Jr. et al., 2008). Gram-negative and gram-positive bacteria, fungi, parasites, and viruses all contain pathogen (or microorganism) associated molecular patterns (PAMPs) that can initiate a septic response (Dellinger & Vincent, 2005; Levy et al., 2010).

The known mechanisms by which various microbiologic organisms trigger a septic response appear to vary. For example, lipopolysaccharide (LPS) is released from the cell wall of gram-negative bacteria. LPS can then bind to LPS-binding protein (LBP) found in plasma. The LPS:LBP complex can then bind with the opsonic receptor *CD14*, predominately expressed on the cell wall of monocytes and macrophages, or with soluble *CD14* (*sCD14*) found in plasma, which is necessary for activation of cells without membrane-bound *CD14*, such as dendritic cells. Antigen-presenting cells (APCs) such as monocytes, macrophages, neutrophils, and dendritic cells can all be activated to release cytokines in response to the protein toll like receptor 4 (TLR4) to further stimulate the release of other cytokines and effector molecules, leading to a cascade effect of increasing inflammation and continued stimulation of the innate immune system response (Dellinger & Vincent, 2005; Levy et al., 2010).

Gram-positive bacteria may also utilize *CD14* and *TLR2* to stimulate cytokine and effector molecule release (Dellinger & Vincent, 2005; Levy et al., 2010). Unlike gram-negative bacteria, gram-positive bacteria do not produce endotoxins such as LPS. Therefore, it is believed that the peptidoglycans and lipoteichoic acid found on the cell walls of gram-positive bacteria are proinflammatory and maybe involved in binding to the above cell-surface receptors, though they are not nearly as potent as LPS (Dellinger & Vincent, 2005; Levy et al., 2010).

The antigen (eg. bacteria) is recognized by a monocyte which immediately releases inflammatory mediators. These mediators include factors such as interleukin-1 (IL-1, IL-6, tumor necrosis factor alpha (TNFα) and tissue factor. These mediators result in a series of responses including initiation of the coagulation cascade, decreased fibrinolysis, and endothelial changes. Toll-like receptors (TLRs), are transmembrane proteins expressed by cells of the innate immune system in response to infection. TLR activation induces the cytokine/chemokine release (ie. TNFα, IL-8) and activation of inflammatory responses. Activation of TLRs in neutrophils can impair the migration of neutrophils and alter immune function (Aitken et al., 2011). Up-regulation of inducible nitric oxide synthase (i-NOS) (NOS-2) protein expression and the consequent enhanced production of nitric oxide is believed to result in excessive vasodilation, vascular hypo reactivity and vascular leak (Alves-Filho et al., 2008).

Although the immune system response is protective in nature, aimed at combating infection in sepsis, increased responsiveness of mediators has been cited as a causal factor in contributing to endothelial cell damage, micro capillary permeability changes, capillary leak, and profound vasodilation and hypotension. Common theories that have been proposed are that sepsis represents an uncontrolled inflammatory response, failure of the immune response to infection, and genetic polymorphisms causing hyper inflammatory or hypoinflammatory responses to infection (C. J. Fernandes, Jr. et al., 2008). More recent theories propose that sepsis results due to a severely compromised immune system response that is dependent on a number of factors including the virulence of the infecting organism, a patient's current health status and severity of illness, nutritional status, age and polymorphisms in cytokine genes or variations in genes that are genetically determined which have been implicated in the pathogenesis of infectious diseases (Salomao et al., 2008). Sepsis is associated with activation of coagulation and impairment of fibrinolysis, which contribute to further impairment in perfusion. Proinflammatory cytokines *IL1* and *TNF*α stimulate the release of tissue factor from monocytes and endothelial cells that directly stimulate the coagulation cascade (Linde-Zwirble & Angus, 2004). A procoagulant state results with increased generation of thrombin and significantly reduced levels of protein C and antithrombin III, which are normal constituents of the anticoagulation system (Linde-Zwirble & Angus, 2004). The resultant microthrombi impairs blood flow and organ perfusion. Thrombocytopenia and disseminated intravascular coagulation can also result. Simultaneously, the normal processes of fibrinolysis are impaired, leading to persistence of microvascular thrombosis that can lead to multiple organ dysfunction (Figure 1) (Balk, 2000).

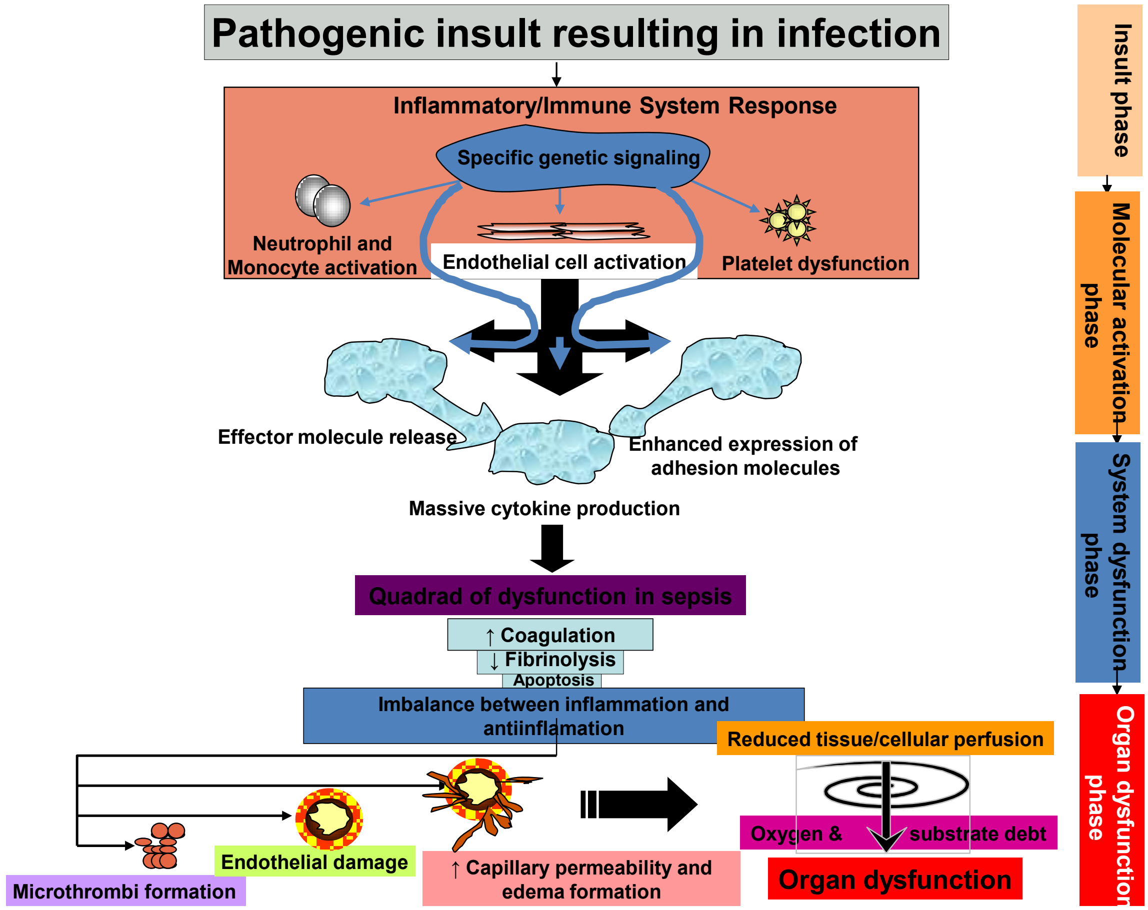

Figure 3-1:

Linking Pathophysiology to Treatment of Septic States

Essential treatment goals for sepsis include antibiotic therapy, supportive treatment with oxygenation and ventilation; and circulatory support with fluid and inotropic administration. The goal of fluid resuscitation is to restore tissue perfusion, and fluid infusion should be titrated to clinical end points, such as heart rate, blood pressure, and urine output (Rhodes et al 2017). Vasopressive agents such as norepinephrine or phenylephrine are indicated if volume infusions do not normalize blood pressure and organ perfusion, as judged by a mean arterial pressure (MAP) of greater than 60 mm Hg and adequate urine output (Rhodes et al 2017).

The Surviving Sepsis Campaign Guidelines provides strategies for targeting treatment of patients at risk of developing sepsis and septic shock (Rhodes et al 2017). The guidelines outline several evidence-based guidelines for the treatment of patients with sepsis. The focus of the Surviving Sepsis Campaign Guidelines are aimed at providing resuscitation for sepsis-induced hypoperfusion and enhancing perfusion; antibiotic administration to combat infection; cultures to identify the source of infection; mechanical ventilation to optimize oxygenation; and source control to identify and contain the infection. The guidelines also advocate for the use of evidence-based treatment practices for critically ill patients including glucose control; prophylaxis measures for deep vein thrombosis and stress ulcer prevention, renal replacement therapies, nutritional support; and blood product administration as indicated. Sedation and analgesia are promoted for patient comfort, and setting goals of care for critically ill patients is advocated to promote realistic treatment goals including decision-making regarding less-aggressive support or withdrawal of support (Rhodes et al 2017).

The sepsis bundles form the main components for implementation. A “bundle” is a group of interventions that when implemented, produce better outcomes than when implemented individually (www.survivingsepsis.org). The Sepsis Resuscitation Bundle (outlined in Table 8), which outline several indicated interventions aimed at stabilizing and further managing the critically ill patient, are advocated to promote optimal management of sepsis.

Table 8: Surviving Sepsis Campaign Care Bundles.

WITHIN 3 HOURS OF SEPSIS:

1. Measure lactate level

2. Obtain blood cultures prior to administration of antibiotics

3. Administer broad spectrum antibiotics

4. Administer 30ml/kg crystalloid for hypotension or lactate ≥4mmol/L

WITHIN 6 HOURS OF INITIAL SYMPTOMS FOR SEPTIC SHOCK:

5. Apply vasopressors (for hypotension that does not respond to initial fluid resuscitation) to maintain a mean arterial pressure (MAP) ≥65mmHg

6. In the event of persistent hypotension after initial fluid administration (MAP < 65 mm Hg) or if initial lactate was ≥4 mmol/L, re-assess volume status and tissue perfusion and document findings

7. Re-measure lactate if initial lactate elevated.

DOCUMENT REASSESSMENT OF VOLUME STATUS AND TISSUE PERFUSION WITH: EITHER • Repeat focused exam (after initial fluid resuscitation) by licensed independent practitioner including vital signs, cardiopulmonary, capillary refill, pulse, and skin findings. OR TWO OF THE FOLLOWING: • Measure CVP • Measure ScvO2 • Bedside cardiovascular ultrasound • Dynamic assessment of fluid responsiveness with passive leg raise or fluid challenge

Source: Adapted from www.survivingsepsis.org. 2017

The Surviving Sepsis Campaign recommendations are graded based on the degree of support from research and focus on improving perfusion, treating the infection, and providing organ system support such as oxygenation and mechanical ventilation, renal replacement therapy for acute renal failure, among other measures to prevent complications of critical illness (Rhodes et al 2017). As nurses are often involved in providing treatment measures to patients, the implications of the guidelines for nursing care are important considerations (Kleinpell, Aitken, & Schorr, 2013).

Several processes can be targeted to ensure successful adoption of the guidelines. Discussion of the guidelines should be incorporated in venues such as daily rounds, grand rounds, and Critical Care Conferences. Other measures to address sepsis as a priority area for ICU care include promoting early identification of sepsis to help in ensuring prompt treatment (Kleinpell et al., 2013). The use of tracking systems such as daily sepsis rounds, use of check sheets to monitor patients for signs of sepsis, or automated computer-based sepsis alert programs can enhance identification of patients with sepsis (Aitken et al., 2011).

Sepsis prevention measures can be instituted, including the use of oral care, head of bed positioning, hand hygiene, and infection control measures. The use of oral care, including tooth brushing, is an essential aspect of care for the critically ill patient to reduce accumulation and colonization of dental plaque that can lead to nosocomial infection risk (Kleinpell et al., 2013). Providing oral care is a direct nursing care measure, yet recent research indicates that inadequate oral care is provided to patients in the ICU. Patient positioning is a key component of nursing care (Aitken et al., 2011). Research evidence suggests that the use of semi recumbent positioning in critically ill patients may reduce ventilator-associated pneumonia. However, the use of recommended levels of backrest elevation (head of bed is 45) can be inconsistent in the critical care environment (Aitken et al., 2011). Hand hygiene measures remain the single most effective means to prevent, control, and reduce infection, as it effectively interrupts microbial transmission from person to person and person to object to person. Infection prevention measures remain critical for limiting infection spread and instituting infection control precautions on the basis of suspected or confirmed infections in critically ill patients is an indicated component of nursing care.

In Case Study Two, the patient was at increased risk for infection due to having had recent surgery with an abdominal incision that required frequent dressing changes, several intravenous lines and invasive catheters. He was also at risk for developing pneumonia as he required prolonged intubation and had difficulty being weaned from the ventilator. He *developed low blood pressure requiring fluid therapy and his urine output began to decline – both signs of altered perfusion. His vital signs changed and his physical exam findings revealed additional signs of progressive shock.*

He also began to manifest signs of sepsis including tachycardia, tachypnea, and elevated temperature. Postoperative lab results revealed an elevated white blood cell count, indicating a potential infection.

When he began to exhibit signs of shock, the most likely etiology was sepsis. His state of impaired oxygenation, hypotension which required fluids and vasopressor therapy, and his decreased urine output demonstrated signs of altered perfusion, classifying him as being in severe sepsis. This was confirmed; and he was started on broad spectrum antibiotic therapy. He required supportive therapy with continued oxygen and mechanical ventilation and on post operative day three. he was afebrile and his vital signs stabilized. By postoperative day five, he was extubated and was transferred to the surgical floor and was ultimately discharged home with home health follow up for assistance with surgical dressing changes.

Multiple Organ Dysfunction Syndrome

A number of factors contribute to multiple organ dysfunction syndrome, the eventual cause of death in sepsis, severe trauma, or hepatic dysfunction, among other causes including: inadequate tissue/organ perfusion, cellular injury, apoptosis-related cell death, ischemia, and diffuse endothelial cell injury (Aird, 2001; Balk, 2000). In addition, end organ damage may be further exacerbated by cardiac and endocrine dysfunction. Impaired cardiac contractility has been linked to the release of myocardial depressant substances early in sepsis (Alves-Filho et al., 2008). Diminished contractility results in increased left ventricular dilation, requiring greater filling pressures in order to meet the delivery demands of the tissues. If compensatory left ventricular dilation does not occur, risk of death from sepsis increases (Dellinger et al., 2013). Adrenal insufficiency and vasopressin deficiency in sepsis contribute to loss of vasomotor control. Insulin deficiency results in hyperglycemia and all its respective sequelae, including impaired wound healing, reduced granulocyte function, and increased risk for infections. Furthermore, insulin deficiency impairs inhibition of both proinflammatory cytokine TNF and proinflammatory intracellular signal transduction by *NF-B*, and may impair macrophage function (Dellinger et al., 2013).

Patients with sepsis have an average of two organ systems that are affected or become dysfunctional (Al-Khafija, 2015). This is associated with a mortality of up to 40%. As other organ systems are affected, mortality rates increase by 15-20% with each additional failure (Al-Khafija, 2015). The implication for clinical practice is significant, as early detection and treatment of organ system dysfunction can prevent increasing rates of mortality in patients with severe sepsis. Clinical criteria and laboratory markers can be used to assess the development and progression of MODS in severe sepsis (see Table 9).

Table 3-6: Commonly Employed Markers of Acute Organ System Dysfunction

ORGAN SYSTEM	MARKER OF DYSFUNCTION	UNDERLYING MECHANISM
Cardiovascular	Tachycardia Dysrhythmias Hypotension Elevated central venous and pulmonary artery pressures	Myocardial depression; altered hemodynamics
Respiratory	Tachypnea Hypoxemia	Altered oxygenation due to capillary leak and impaired gas exchange
Renal	Oliguria Anuria Elevated serum creatinine	Reduced renal perfusion and the onset of acute renal failure/acute kidney injury
Hepatic	Jaundice Elevated serum level of liver enzymes Decreased serum albumin Coagulopathy	Onset of hepatic failure; impaired perfusion; coagulopathies
Hematologic	Thrombocytopenia Coagulopathy Decreased Protein C levels Increased D-dimer levels	Low platelet count is often due to decreased production; coagulopathies develop due to stimulation of the coagulation cascade by proinflammatory mediators or cytokines; Platelet aggregation and thrombi form because of the increased viscosity of the blood.
Neurologic	Altered consciousness Confusion Pyschosis	A depressed level of consciousness may occur with sepsis; the specific cause is

		unknown but may be related to altered perfusion or the effects of cytokines

Adapted from Balk RA. Severe sepsis and septic shock. Definitions, epidemiology, and clinical manifestations. Critical Care Clinics 2000; 16:179-192.

International Considerations

The incidence of sepsis in low middle income countries (LMICs), and its consequent burden of mortality are currently not known (Adhikari et al, 2010). Epidemiological studies of sepsis in the USA and elsewhere were slow to emerge, considering the burden of illness and mortality. In LMICs, no population studies of sepsis exist to date. However, groups at risk of sepsis in LMICs are:

- HIV (Odd Ratio for BSI=3.4, Reddy et al, 2010)
- Maternal complications (approx. 10% of all maternal mortality, Khan et al, 2006)
- Diabetes (25-75% increased risk of sepsis, Hall et al, 2011)
- Hospital Acquired Infections (15% In-patients will contract a nosocomial infection in LMICs, Allegranzi et al, 2010)

LMIC mortality data

- Median (and mean) mortality rates for sepsis and septic shock can be calculated for LMIC's as 44.95% (45.67%) and 53.35% (62.86%) respectively, compared to a severe sepsis mortality rate of 28.6% in the US.
- Brazil – Overall mortality vs. sepsis mortality (21-29% for all cause in hospital mortality vs. 51.6 – 56.8% with severe sepsis; Kauss et al, 2011, Silva et al, 2004).
- Uganda – all cause in-hospital mortality of 15.4% compared to an in-hospital mortality of 23.7% and a 28 day-mortality of 43.0% for patients with sepsis (Jacob et al, 2009).

Specific considerations relate to the ability to confirm a clinical diagnosis in LMICs as there is limited availability to diagnose by blood or other microbiological cultures and the clinical coding may be unreliable or unavailable in many LMICs. Sepsis presents an extraordinary medical and economic challenge for LMICs. With early recognition, aggressive fluid resuscitation and early goal directed therapy; outcome of sepsis can be improved. However, in resource poor settings this can be quite challenging (Kabara et al 2013). The key concepts of sepsis management are potentially translatable to LMIC's and health personnel should be educated in recognition of sepsis early and appropriate antibiotic use. Simple and low-cost standardised laboratory testing should be available, and evidence-based interventions and treatment algorithms tailored to LMIC countries should be developed and validated.

CHECK YOUR PROGRESS: Assess your understanding of key points from the previous sections.

- Cardiogenic shock is caused by inability of the heart to pump adequate amounts of blood to meet cellular needs. It is most often caused by a massive myocardial infarction. Pulmonary edema occurs in cardiogenic shock because blood backs up into the lungs and increases hydrostatic pressure in the pulmonary capillaries.
- Hypovolemic shock is caused by loss of whole blood or plasma from the body or shifting of large amount of fluid out of the vascular space into the interstitial space. The decreased blood volume results in decreased venous return to the heart, decreased cardiac preload, and decreased cardiac output.
- Anaphylactic shock occurs as a result of a severe systemic allergic reaction. Hypotension in anaphylactic shock is due to massive vasodilation and loss of circulating blood volume caused by increased vascular permeability resulting in fluid leakage out of the vascular compartment.
- Neurogenic shock, which is also called vasogenic shock, occurs when there is disruption of the neural output from the central nervous system to the blood vessels. Head injury or spinal cord injury is a common cause of neurogenic shock.

• Septic shock is caused by a serious systemic infection. In many individuals, septic shock is associated with an intense inflammatory response caused by the infection with cell injury resulting from the inflammation as well as activation of the complement and coagulation systems. However, septic shock can also cause immune paralysis leaving the individual susceptible to a variety of nosocomial infections.

• Multiple organ dysfunction syndrome can occur as an end result of altered perfusion. Mortality rates increase as the number of organ system failures increase. Shock is difficult to reverse once multiple organ dysfunction occurs. Therefore early recognition and treatment to improve organ system perfusion are key components to managing multiple organ dysfunction.

1. What is the most common form of shock?

   a. Cardiogenic

   b. Neurogenic

   c. Septic

   d. Anaphylactic

   e. Hypovolemic

Answer: E, hypovolemic shock is the most common form of shock

2. Signs of sepsis include changes in vital signs. Which of the following is not seen in patients with sepsis?

   a. Decreased blood pressure

   b. Increased heart rate

   c. Decreased respiratory rate

   d. Elevated temperature

Answer: C. An increase in respiratory rate is often seen in sepsis due to the development of hypoxemia and a compensatory response to increase oxygenation.

3. Which type of shock can progress rapidly to a life-threatening state?

a. Cardiogenic

b. Neurogenic

c. Septic

d. Anaphylactic

e. Hypovolemic

Answer: D, anaphylactic shock can progress rapidly to a life-threatening state due to profound hypotension and airway compromise that can result from brochoconstriction.

Chapter Summary

Shock is a clinical syndrome that results from inadequate oxygenation and tissue perfusion. Shock is classified based on the etiology into several categories including hypovolemic, cardiogenic, distributive, or obstructive shock. In shock, a number of cellular, metabolic and hemodynamic alterations occur that result in alterations in oxygen delivery and perfusion. Shock can progress from the initial stage through the compensatory, progressive and refractory stages if compensatory mechanisms are unable to maintain perfusion to vital organs. Cardiogenic shock results from inadequate tissue perfusion from myocardial dysfunction, which leads to cellular hypoxia and ischemia. Cardiogenic shock is often characterized by both systolic and diastolic myocardial dysfunction. Hypovolemic shock, the most common form of shock, results from loss of blood, loss of plasma volume of greater than 20% of the circulating volume, or from profound dehydration. Anaphylactic shock results from an allergic reaction that causes systemic release of IgE (antibody formed as part of immune response) and causes mast cell activation and histamine release

Neurogenic shock, the rarest form of shock, results from loss of peripheral sympathetic vasomotor tone and changes in systemic vascular resistance mediated by a neurologic injury, often due to spinal cord injury.

Sepsis is systemic infection that can progress to septic shock, in which severe hypotension results that is unresponsive to fluid therapy and medical treatment. Multiple organ system dysfunction can result which has a high mortality rate in patients with shock. Treatment goals for shock are focused on improving perfusion along with the ABC's of shock management: airway, breathing and circulation. Additional specific treatment measures based on the type of shock include: fluid and blood replacement for hypovolemic shock; reversal of severe vasodilation due to histamine and mediator release in anaphylactic shock; and antibiotic therapy for septic shock, along with organ support measures such as supplemental oxygenation and mechanical ventilation, renal replacement therapy for acute renal failure, and other measures to prevent the complications of critical illness.

Key clinical care priority areas include: monitoring patients for evidence of developing shock and organ dysfunction, identifying patients at risk for shock and sepsis, promoting early identification, and instituting treatment measures (Kleinpell et al 2013).

End of Chapter Multiple Choice Questions

1) All of the following except which condition can lead to a state of shock?

    A. Allergic reaction

    B. Severe myocardial infarction

    C. Systemic infection

    D. Pregnancy

Answer: D.

Rationale: While complications of pregnancy such as bleeding can predispose a patient to shock, pregnancy in and of itself does not lead to a state of shock. An allergic reaction can lead to anaphylactic shock. A severe myocardial infarction can predispose a patient to developing cardiogenic shock. A systemic infection can progress to sepsis and septic shock.

2) Which of the following is NOT considered a sign of shock?

A. Tachycardia

B. Pale skin

C. Decreased urine output

D. Hypertension

Answer: D

Rationale: Hypertension is not considered a sign of shock; rather, hypotension is commonly seen in shock.

Other signs of shock include tachycardia as a compensatory response and a result of sympathetic nervous system activation, pale skin which occurs due to vasoconstriction to maintain perfusion to vital organs, and decreased urine output which results from a decreased cardiac output to the kidneys.

3) What is the primary aim of treatment in shock states?

A. Increase blood pressure

B. Decrease heart rate

C. Increase perfusion

D. Decrease acidosis

Answer: C

Rationale: The primary aim in the treatment of shock is to increase perfusion. Shock results due to an alteration of perfusion. While hypotension is commonly seen in shock, increasing the blood pressure may not sufficiently increase perfusion. Acidosis may be present in shock but is often a late manifestation.

4) Which of the following is a sign of neurogenic shock that is not seen in other forms of shock?

A. Hypotension

B. Hyperthermia

C. Tachypnea

D. Bradycardia

Answer: D

Rationale: Bradycardia occurs in neurogenic shock as a result of the loss of normal sympathetic nervous system response and a resultant unopposed vagal tone.

Neurogenic shock is a distributive type of shock resulting in hypotension, occasionally with bradycardia, that is attributed to the disruption of the autonomic pathways within the spinal cord.

5) Which of the following is a first-line agent for treating anaphylactic shock?

A. Steroids

B. Antihistamines

C. Bronchodilators

D. Epinephrine

Answer: D

Rationale: Epinephrine is a first-line agent for anaphylaxis because it promotes vasoconstriction, along with inhibiting the further release of mediators

Antihistamines, which block the release of histamine, are considered second line agents for treating anaphylactic shock.

Bronchodilators and corticosteroids are also considered second-line agents that reduce additional symptoms including respiratory stridor and wheezing and potentially late-phase reactions.

6) What type of shock is associated with the highest mortality rate?

A. Cardiogenic
B. Anaphylactic
C. Neurogenic
D. Septic

Answer: D

Rationale: Septic shock is associated with the highest mortality rate – 28% to 50% or more depending on the number of organ systems involved with altered perfusion.

While cardiogenic shock has a high mortality up of to 50%, septic shock mortality rates can exceed 60% or more when 3 or more organs are involved in multiple organ dysfunction syndrome.

7) Which of the following is NOT considered a sign of sepsis?

A. Tachycardia
B. Tachypnea
C. Hypertension
D. Elevated white blood cell count

Answer: C

Rationale: Hypertension is not considered a sign of sepsis.

The signs of sepsis include tachycardia, or an elevated heart rate, tachypnea, or an elevated respiratory rate, an elevated temperature (or hypothermia) and an elevated white blood cell count and/or greater than 10% bands or immature neutrophils, also termed bandemia.

8) Which of the following is NOT a cause of cardiogenic shock?

A. Cardiomyopathy

B. Dysrhythmias

C. Pericardial tamponade

D. Cardiac transplant rejection

Answer: D

Rationale: Recognized causes of cardiogenic shock include cardiomyopathies, dysrhythmias and pericardial tamponade.

Cardiac transplant rejection is not associated with cardiogenic shock

9) What term describes sepsis with acute organ dysfunction?

A. Septic shock

B. Septicemia

C. Sepsis

D. Multiple organ dysfunction syndrome

Answer: A

Rationale: Septic shock designates progression of sepsis with the manifestation of organ dysfunction.

Septic shock is caused by decreased tissue perfusion and oxygen delivery as a result of severe infection and sepsis and often is manifested by severe hypotension that is unresponsive to treatment.

Septicemia is the medical term referring to the presence of pathogenic organisms in the bloodstream.

Multiple organ dysfunction syndrome (MODS) signifies the involvement of more than one organ system dysfunction due to altered perfusion in severe sepsis. MODS is associated with high mortality rates.

10. Which of the following is NOT a commonly employed marker of acute organ system dysfunction?

A. Jaundice

B. Thrombocytopenia

C. Hypotension

D. Decreased creatinine levels

Answer: D.

Rationale: Increased creatinine levels are a sign of acute organ system dysfunction, specifically acute renal failure or acute kidney injury. Jaundice may be seen due to hepatic dysfunction. Thrombocytopenia or a decrease in platelets may occur due to decreased production, due to bone marrow suppression. Hypotension is a common presenting sign of acute cardiovascular organ system dysfunction in shock states.

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Chapter 4

Safety and Quality in the ICU

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Learning Outcomes

After completing this e-chapter you will be able to:

1. Discuss the importance of patient safety as a discipline.

2. Identify learnings on patient safety.

3. Be motivated by the sharing of a Philippine quality story.

4. Implement safety control principles

5. Define Total Quality management.

6. Describe the Demming cycle

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Safety in ICU

The critical care unit remains to be one of the challenging areas in the hospital that is besiege with high intensity care and activity. It is the place where the sickest patents are kept for vigorous round the clock monitoring and management, and as such iatrogenic complications in the critical care units are inevitable, often leading to medical emergencies. Iatrogenic complication results from the activity of a health care provider, or an adverse condition in a patient resulting from treatment by a physician, nurse or allied health professional. Human errors account for most of them, affecting the elderly and the most severely ill patients (Laskou et al, 2006). This situation may affect the clinical course of patients by increasing morbidity and mortality. An error is defined as the failure of a planned action to be completed as or the use of a wrong plan to achieve an aim (Reason, 1990).

In 1981 the red flag was raised for the medical community to articulate the serious risk associated with hospitalization. Despite the many advances of diagnostics and therapeutic interventions at this time, it has not matched the reduction in iatrogenic illness suffered by patients in the hospital (Steel et al, 2004). Until now the health care industry strives to identify measures that will improve and make progress to keep the patient safe. Aptly to say the World Health Organization provided the simplest definition of patient safety by stating that this is the prevention of errors and adverse effects to patients associated with health care.

Vigilance in care remains to be top priority skills amongst the health care practitioner in this area to keep patient safe. However, studies have shown that a great number of patients still suffer from adverse events and error while critical care is instituted. As a response to this grim scenario, patient safety is a new discipline that emphasizes the reporting, analysis and prevention of medical error that often leads to adverse healthcare events.

An important aspect to this realization of preventing patient harm has been the growth of interest in patient safety. It is increasingly clear that patient safety has become a discipline, complete with an integrated body of knowledge and expertise, and that it has the potential to revolutionize health care, perhaps as radically as molecular biology once dramatically increased the therapeutic power in medicine (Emanuel et al, 2008). According to the Patient Safety Alliance, the frequency and magnitude of avoidable adverse patient events was not well known until in 1990s, when multiple countries reported staggering numbers of patients harmed and killed by medical errors. Recognizing that healthcare errors impact 1 in every 10 patients around the world, the World Health Organization calls patient safety an endemic concern (WHO, 2008)

Learnings on Patient Safety

The field of patient safety is maturing rapidly. More training on safety awareness are provided for the healthcare practitioners; clinicians and researchers are designing interventions, health systems are implementing safety initiatives and programs, regulators are evaluating practices and governments are launching national health care safety agencies. Globally, even in the developing areas of the world, WHO itself is implementing safety projects with its international partners.

In the last decade, the global community learned about the nature of safety in health care. The article published in the WHO Patient Safety website written by Pronovost stated the following learnings: there are no quick fixes to this problem of patient safety; measures must be meaningful and valid to the clinicians who ultimately have to use them to improve safety; science is necessary to ensure that patients are really safe; and no one discipline or single theory alone will be sufficient (Pronovost, n.d.)

Critical care nurses and administrators strive to prevent errors from happening and have instituted various initiatives and interventions to promote patient safety. It is with the understanding that the key to the attainment of safety is the development of a culture of safety amongst the healthcare providers caring for the critically ill. Likewise, efforts should be exerted to identify the common factors contributing to error or adverse event so that a viable and appropriate solution can be developed.

Philippine Scenario on Patient Safety

The Philippines, as a developing country, is striving to attain safety culture in health care. As a country, it is besieged with challenges in health care that impact on safety. The factors relevant to these challenges are the following: issues on human resource for health such as nursing supply and demand; changes in the disease pattern and implementation of health care safety systems.

The human resources for health in the Philippines are enormous but unevenly distributed. There is a maldistribution of health professionals, stemming from the lack of budget for the human resource for health positions or plantilla items. The nurse-to-population ratio is about 0.31 per 1000 people in 1993, but since then, this number grew dramatically to 4.43 per 1000 in 2000 and stabilized until 2005 (WHO-WPRO, 2013). This large increase was mainly due to the high demand for nurses in other countries, thus making the Philippines the major source of health professional to other countries.

The social forces of globalization and urbanization that shape today's civilization, has influenced the changes in the Philippines' disease patterns. Fifty percent (50%) of disease pattern are related to non-communicable disease. The burden of these specific diseases is heavily concentrated on the young and working adults or the poor (Ravichandran, n.d.). Likewise, cyclones and typhoons in the Philippines are causing frequent mudslide flooding leading to other communicable disease.

These events brought about by the maldistribution of human resource for health, demographic trend of disease burden, financial pressures and the demand for health care and nursing service leads to combination of circumstances that aggravates the health care situation and patient safety in the Philippines.

A Quality Story on Patient Safety

Confronted by the identified challenges, the health practitioners in the Philippines manage to make great efforts in attaining patient safety. Guided by the Institute of Medicine's principles of "safe, effective, patient-centered, timely, efficient and equitable (IOM, 2001)" care, initiatives and programs are innovatively designed and implemented to ensure that the patients they cared for are safe.

Critical care nurses in the Philippines share their innovative patient safety practices during the yearly congress of the Critical Care Nurses Association of the Philippines, Inc. (CCNAPI). Their innovative practices emphasize that safety and quality are concepts on a continuum. A quality story that was shared during the 2014 CCNAPI Congress demonstrated safety and quality continuum while the nurses implement the safety practice on pressure ulcer prevention. For the purpose of sharing, this story from neurocritical care nurses in a tertiary hospital will be discussed in this article. It emphasized that safety simply will go beyond turning.

Beyond turning. This quality story was presented by nurses from the Neurocritical Care Unit & Epilepsy Monitoring Unit (NCU-EMU). The team was composed of 18 critical care nurses, a nurse manager and a neuro-intensivist and they were so concerned about the occurrence of pressure ulcers inn their unit. With the commitment and desire to put patient's safety first, they strived to succeed, prevail and overcome the pressure ulcer concern threating the safety of the patient….and so they started to know their facts.

The data as shown in Figure 1 revealed a diminishing trend in the occurrence of pressure ulcer until an absolute "zero" was attained. This summarizes the achievement that they had after instituting the quality measures on the project against pressure ulcers.

How was this possible? The NCU-EMU team adopted the Six Sigma techniques as the tool for process improvement. Six Sigma seeks to improve the quality of process outputs by identifying and removing the causes of defects (errors) and minimizing variability in manufacturing and business processes. Originally developed in 1996 by Motorola, the business management strategy is now used in many different industries in an effort to improve the quality or products or services produced by the business through the removal of defects and error (BusinesDictionary.com).

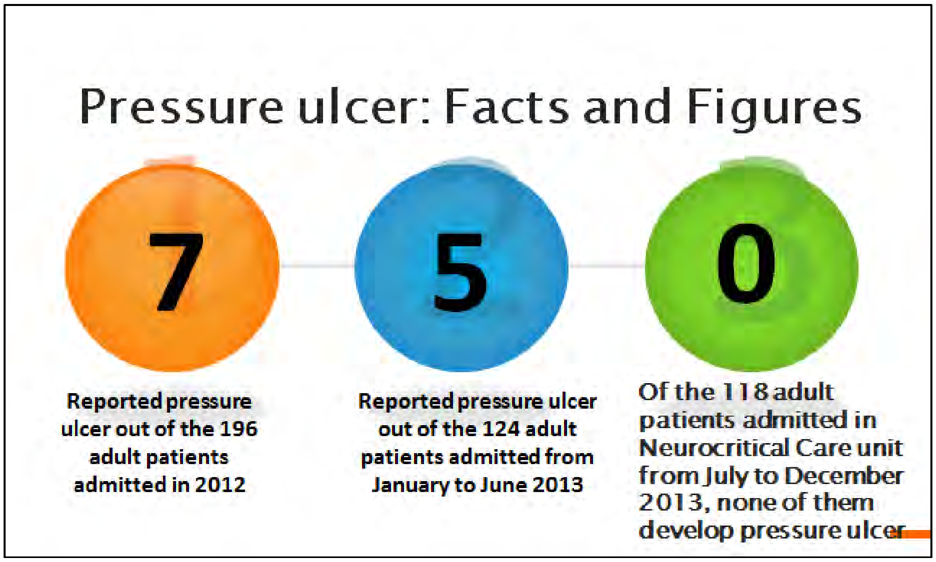

Figure 4-1: NCU-EMU Data on pressure ulcers

The safety project entitled "Beyond Turning: Reducing the rate of hospital-acquired pressure ulcer" addresses the challenges and opportunities of pressure ulcer prevention to the nursing workforce. The project required five phased of the Six Sigma: Design – Measure – Analyze – Improve – Control.

The first phase – Define is summarized in In Figure 2 by showing the project description in terms of the problem/issue, purpose/ objective, importance, expected deliverables and project scope.

Project Description	
Problem or Issue	Pressure ulcers are difficult to treat and costly but most of them are preventable if good clinical practice is strictly followed. Prevention, early detection and appropriate management are essential elements needed to eliminate, if not minimize the incidence of pressure ulcers. However, despite of the availability of resources on PU prevention a considerable number of cases of pressure ulcer particularly hospital-acquired are still being reported.
Purpose or Objective	*Examine current state of hospital-acquired pressure ulcer in the hospital especially among Neuro-ICU patients *Determine contributing risk factors of pressure ulcer development in critical care unit. *Develop action plan that will address pressure ulcer development. *Develop reference guide in preventing and managing pressure ulcer. *Reduce the rate of Hospital-acquire Pressure Ulcer by 50%.
Importance	This study will address the challenges and opportunities of pressure ulcer prevention to the nursing workforce. Moreover, this study aims to eradicate, if not reduce the number of reported hospital-acquired pressure ulcer thereby delivering better quality nursing care.
Expected Deliverables	This study is expected to create improvement in the prevention, detection and management of pressure ulcer. Likewise, reference guide and Bundle of Care for pressure ulcer are expected written output.
Project Scope	Patients who are 19 years old and up and admitted at the Neurocritical care unit within 24 hours are the scope of this project. Patients with pressure ulcer at the time of admission, either hospital-acquired or home-acquired, are not included in this study.

Figure 4-2: Beyond Turning Project Description

The second phase – Measure was demonstrated in Figure 3 which showed the data measured from January 2012 to July 2013. The team studied the trend and focused on the numbers. They closely examined the factors that can be attributed to the occurrence of the pressure ulcers.

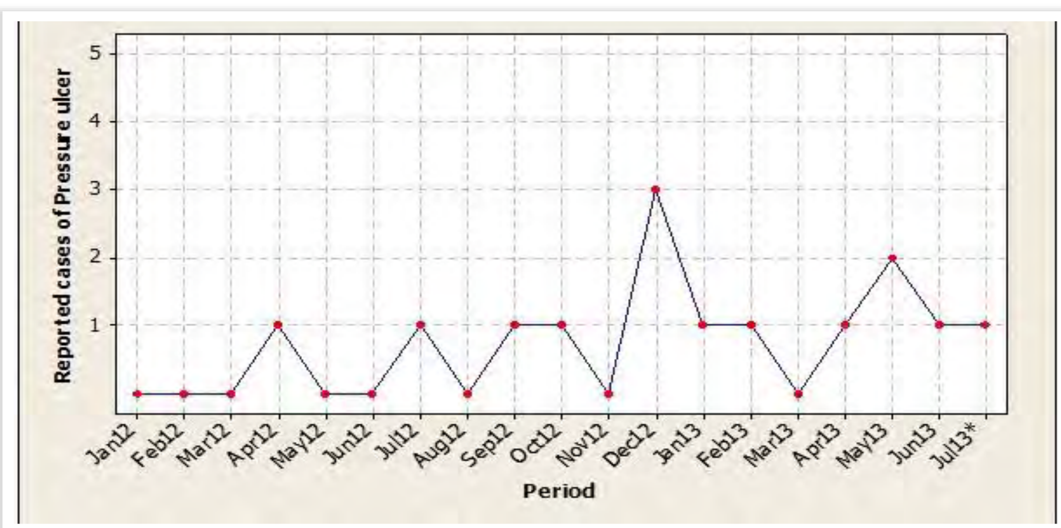

Figure 4-3: Number of reported HAPU in NCU-EMU

The third phase – Analyze was demonstrated in Figure 4. Ishikawa Fishbone diagram also called Cause-and-Effect diagram identifies many possible cause for an effect or a problem (ASQ, 2005). The NCU-EMU team used this diagram structure to brainstorm on the pressure ulcer concern because it immediately sorts the ideas into useful categories. Figure 5 on the other hand shows the frequency distribution of the factors related to the presence of hospital acquired pressure ulcers. Surprisingly, the brainstorming of the NCU-EMU team presented that the factor with highest frequency pertains to the lack of proper knowledge on pressure ulcers common among the nurses. The nurses realized that the skin care issues previously reported as pressure ulcer were not really pressure ulcers in the strictest sense and that not all pressure ulcers are preventable.

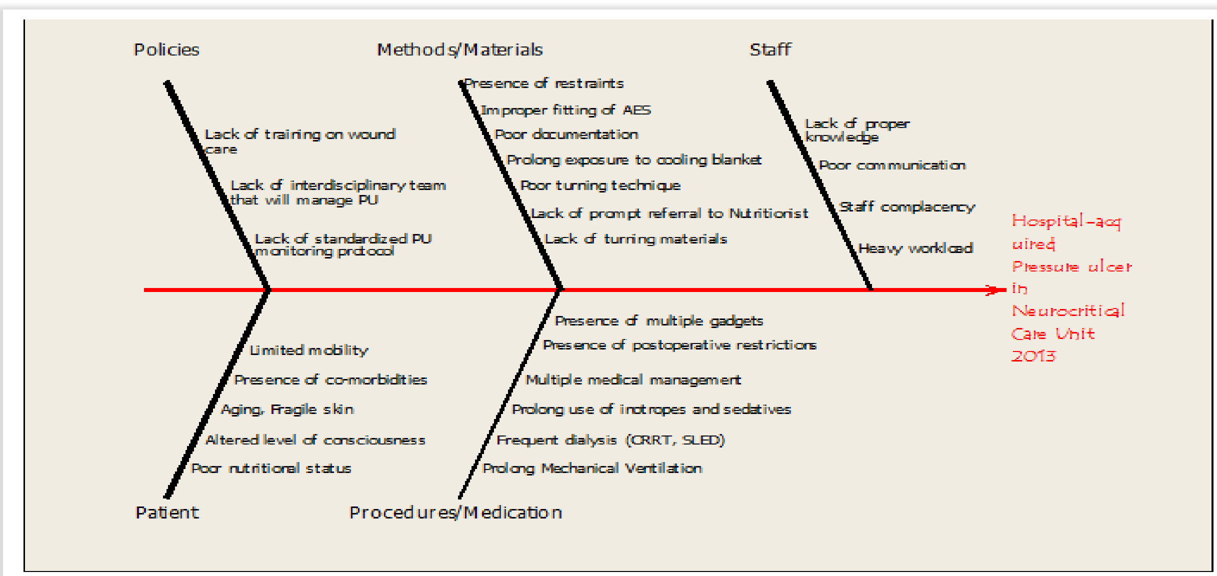

Figure 4-4: Ishikawa Fishbone Diagram for HAPU in NCU-EMU

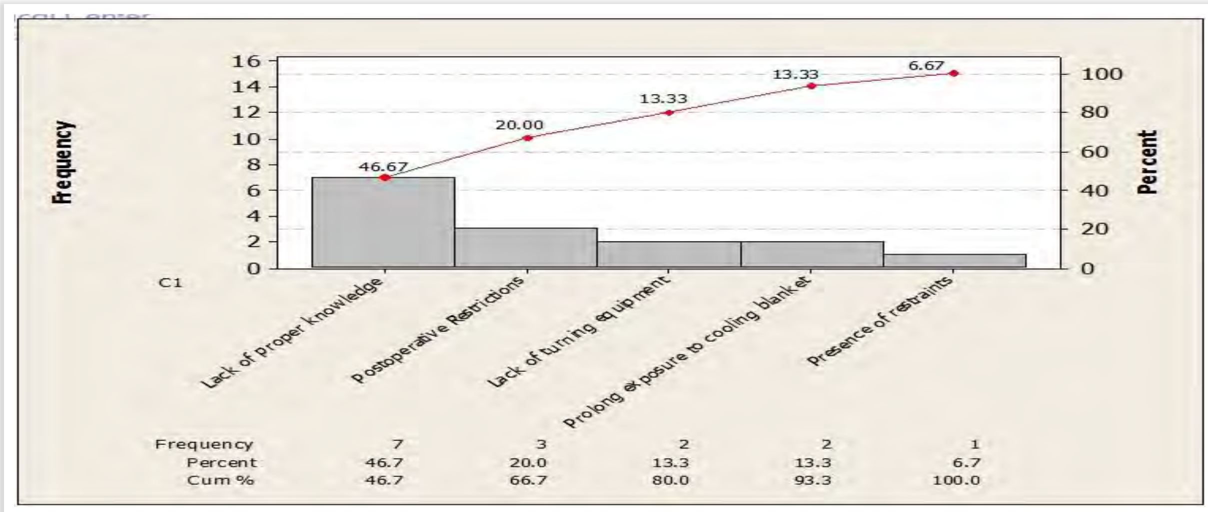

Figure 4-5: Frequency Distribution of Factors Related to HAPU

The fourth phase – Improve made the NCU-EMU team formulate the goal to be achieved by the project. The goal was “reduction of hospital-acquired pressure ulcer by fifty percent (50%) in six months”. An orientation on the process improvement “Beyond Turning” was made. Figure 6: Spread the Message demonstrated the great enthusiasm of the NCU-EMU nurses during the orientation.

Figure 4-6: Spread the Message

The orientation focused on educating the nurses on the definition of pressure ulcers and the stages of pressure ulcers following the guidelines of the National Pressure Ulcer Advisory Panel. The action did not stop with the orientation. The NCU-EMU team made their campaign visible and the nurses continued gaining knowledge through on-line courses, likewise, the team did not forget the patient's family. They involved the family in the plan of care for the patient and educated them on things they have to know about skin care and pressure ulcers, making the family partners in care.

The final phase of Six Sigma technique – Control was established by the team by putting a benchmark. Figure 7 shows the comparison of the data from the NCU-EMU with the benchmark data from NPUAP –EPUAP (2009). The data demonstrated a 42% decrease in HAPU in 2013 or after six months of implementing actions for the project. The team understood that at the end of the improvements, it is necessary to calculate new process control limits and make these limits the triggers for corrective and preventive action (Six Sigma Materials, n.d.).

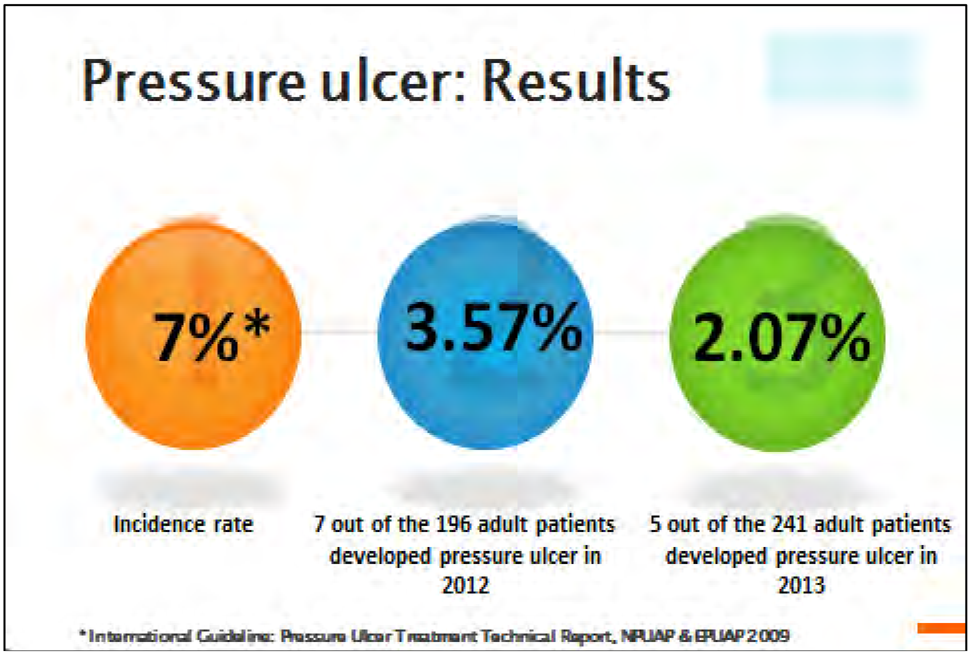

Figure 4-7: Pressure Ulcer Results

These neurocritical care nurses summarized their personal and professional learning as follows:

- KNOWING is one thing. UNDERSTANDING is another thing
- Nothing is great than EVIDENCE-BASE PRACTICE
- GREAT things come from SMALL beginnings
- TEAM work divides the task and multiplies the success
- CHANGE is easier when you know where you are going and why it’s worth it.

Conclusion

Patient safety has gone along way, from what started as a concern, this is now a discipline. New body of knowledge, improving science and supporting the learnings with evidences are just some of the imperatives for the change we have to move to keep our patient safe from most of the advance practices and technologies that also evolved. As nurses and healthcare providers we always bear in mind and conscience the Hippocratic Oath of "*Primum non nocere"*(first, do no harm).

Quality Control

Quality is defined as a set of properties and characteristics of products, processes or services that relate to the possibility of meeting the stipulated or implied needs. That portion of the product or service with minimal costs in the life cycle contributes to a maximum of purpose and health of the people involved in its production, distribution, use, maintenance and recycling, and with a low cost of all resources, and with an acceptable impact on society and the environment. This includes quality of the integration of work and the integration of responsibilities. Total Quality Management (TQM) is a comprehensive and structured approach to organizational management that seeks to improve the quality of products and services through ongoing refinements in response to continuous feedback. Total Quality Management involves the user, the philosophy of management to ensure the leadership, training and motivation for the purpose of continuous improvement of organizational processes (John M. Kelly). Quality control is a function of management in which the work is monitored, measured and remedial action in order to meet anticipated organizational goals. Quality management is the measurement and correction of all procedures in the process of work, in accordance with the adopted plan and goals of health care.

The basic principles of TQM:

- User determines the quality
- Top management leads and takes the initiative
- Elimination of variation
- Continuous improvement with the use of measuring instruments (data and facts)

Nursing standards are measurable definitions agreed and acceptable quality of nursing care at the specific workplace which is judged and evaluated current nursing practice. Define standards can be done by the head nurse or director at the level of institutions, but in every respect the most acceptable standards are addopted and accepted by all the nurses at the level of the Council, the Association or the other relevant institutions. They act as guidelines or objectives which determines whether the nursing activities certain quality. Standard defines a coherent level of quality and quantity of work. Standards are established rules that are used in measuring or defining the quality and value of services or procedures. Standards must be clear, realistic, acceptable and understandable. Standards of medical care must be adopted by the nurses, and based on knowledge and scientific basis.

Continuous quality improvement is a tool for improving the quality of services provided by organisations. Continuous quality improvement refers to having a systematic approach to collecting and reviewing data or information in order to identify opportunities to improve the operations of an organisation with the end result of delivering better services to customer or clients. A common approach to continuous quality improvement is to see it as an ongoing cycle involving planning, doing, checking, identifying more actions and then starting again that is Demming cycle shown in Fig.1.

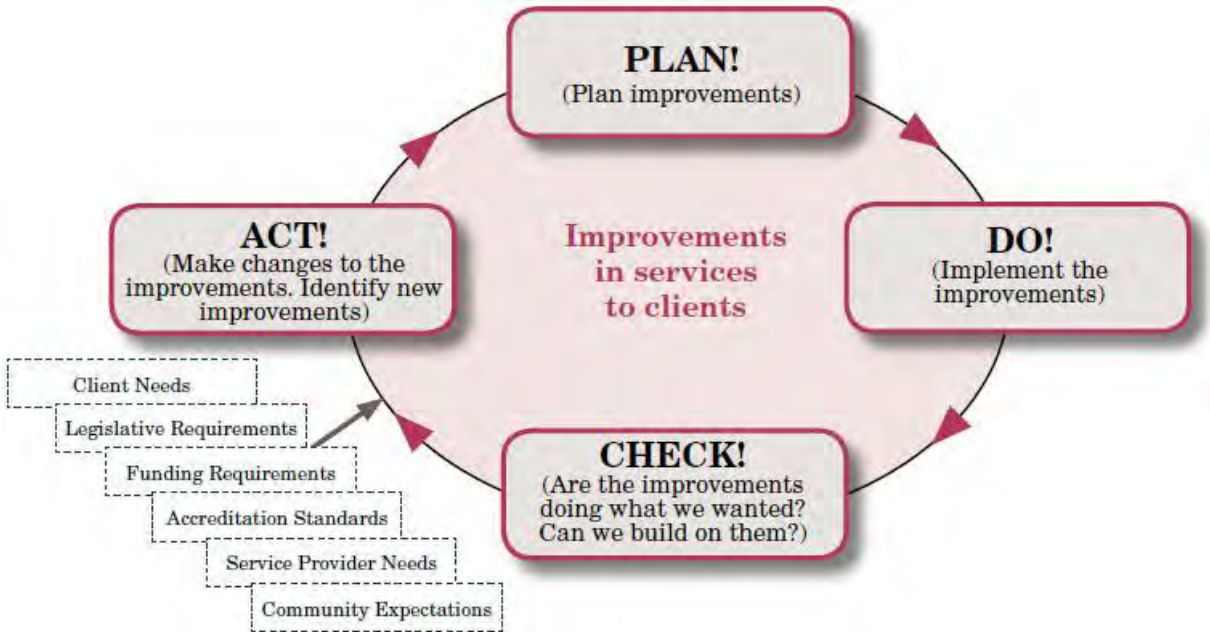

Figure 4-8:

Quality Indicators in ICU

Full access to quality management it is possible to establish the implementation of the quality management system, defining the quality policy and procedures but which enable quality assurance and control. The principle of total quality management is a specific structure of an organization that provides services and products and at the same time striving to fully meet the needs of its clients. Quality indicators are quantitative measures of an important aspect of the service that determines if service set standards or requirements. Quality indicators are at the core of the program quality improvement together with the criteria for monitoring staff and show which parts of the standards achieved.

Quality indicators are measurable, objective, quantitative indicators of the effectiveness of key system elements. Indicators show us the extent to which the system meets the needs and expectations of users. Systematic collection and analysis of quality indicators is the obligation of all accredited institutions. Indicators should have a very clear and unambiguous definition and interpretation, and the measurability of indicators is an essential prerequisite for their successful establishment. They must be related to the quality of the key, strategic and supporting processes.

The most common quality indicators in ICU:

- Nurse - patient ratio
- Skin integrity
- The amount of health care provided to the patient during the day
- Patient satisfaction with pain therapy
- patient satisfaction with provided information
- Patient satisfaction with nursing care
- Satisfaction of patients overall health care
- Nosocomial infections
- Nurses satisfaction

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Chapter 5

Recognizing and managing the deteriorating patient: The role of Rapid Response Systems, Critical Care Outreach Nurse and Medical Emergency Teams

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Learning Objectives

After completing this chapter you will be able to:

1. Identify the characteristics and early warning signs of the deteriorating patient outside the ICU.
2. Explain the role of early warning systems for activation of rapid response in the hospital setting.
3. Identity characteristics of a rapid response system.
4. Understand the role, activities and operation of critical care outreach nurses (CCONs)
5. Identify the skills, attributes, education and training requirements of CCONs.
6. Understand the evidence supporting the effectiveness of outreach services.
7. Identify future directions for organizing an outreach service.

8. Describe the administrative and governance structures necessary for establishing, implementing, monitoring and improving RRS performance.
9. Identify future directions of RRSs

Definitions

RRS - Rapid Response System

RRT - Rapid Response Team

MET - Medical Emergency Team

CCOT - Critical Care Outreach Team

CCON - Critical Care Outreach Nurse

EMR – Electronic Medical Record

EWS - Early Warning System/Score

PEWS - Paediatric Early Warning System/Score

MOEWS - Maternity/Obstetric Early Warning System/Score

Chapter Overview

The last decades have witnessed the emergence of a new strategy to identify and respond to clinical deterioration in acute care hospitals, the Rapid Response System (RRS)/Medical Emergency Teams (MET) (Jones, Bellomo, & DeVita, 2009; Jones, Lippert, DeVita, & Hillman, 2015). This concern emerged due to the increased acuity of ward patients (Armitage, Eddleston, & Stokes, 2007; Australian Commission on Safety and Quality in Health Care (ACSQHC), 2012), the limited beds in ICU and limited critical care resources in ward services. Critical care outreach nurses (CCON) have played a pivotal role in the development, operation and management of RRSs (Niven, Bastos, & Stelfox, 2014; Stelfox, Bagshaw, & Gao, 2014) whether they are medical or nurse led (Devita et al., 2006). MET has become an accreditation requirement in some countries and is a highly recommended strategy for recognising and responding to clinical deterioration in acute care hospitals (Australian Commission on Safety and Quality in Health Care (ACSQHC), 2012).

Critical care nurses contribution to management of patient deterioration on the wards is noteworthy. Called critical care or intensive care outreach nurses, nurse at night, clinical team coordinators, ICU liaison nurses and many other terms, all are clinical experts, who use advanced assessment, technical, teaching and communication skills to both assist in the care of complex patients and support nurses who are providing care to these patients (Alberto et al., 2014; Chaboyer, Foster, Foster, & Kendall, 2004; Green & Edmonds, 2004; Williams, Hughes, Timms, & Raftery, 2012). Patients discharged from ICU are also vulnerable to clinical deterioration as they are recovering from a critical illness (Stelfox et al., 2014). Early identification of clinical deterioration and a trigger response mechanism is critical to ensure early help and intervention (Eliott, Chaboyer, Ernest, Doric, & Endacott, 2012; Priestley et al., 2004).

This chapter introduces the RRS/MET systems and the use of CCONs, how to organize and implement a hospital wide response system, and how to monitor and improve early recognition and management of the deteriorating patient. It also describes the role of CCON, the competences required, and the variation in current practice across settings and countries.

Introduction of Chapter Case

Case Study: A 59-year-old male has already arrived to a medical ward. At his admission he referred to having been sick for a few days, with mucous diarrhea and abdominal pain. He had come to the emergency department a week ago and was discharged home with treatment of symptoms and antibiotics. The pain and diarrhea continued, in the last 48 hours he reported repeated episodes of bleeding stools and fever; then came to the emergency department again. Emergency practitioners initiated IV fluid administration, prescribed clostridium difficile toxin and other lab tests, abdominal ultrasound and colonoscopy.

After 12 hours in emergency department he was transferred to the medical ward. Abdominal ultrasound evidenced bowel inflammation. The colonoscopy reported the formation of pouches within the bowel wall actively bleeding.

The patient is awake and responsive. Initial physical exam reveals pale skin, slow/sluggish capillary refill, ill in appearance. Abdomen is soft with hyperactive bowel sounds. Hypertension, diabetes and anaemia are conditions of previous health history referred by the patient's wife. His is receiving fluids by peripheral IV.

Current vital signs: BP: 110/60 mmhg, HR: 130, Temp: 37.8°C, Respirations: 28

An hour after arriving to the medical ward the patient's wife calls the nurse in charge because her husband has suddenly become less responsive, and she hasn't seen his treating doctor.

Recognition and Management of the Deteriorating Patient

Risk to patient harm and death is lowered when complications and deterioration are recognized quickly and treated aggressively. This is an intuitively obvious premise, that is, the earlier the complication is recognized and acted upon, the less likely a negative outcome will occur… *a stitch in time saves nine!*.

However numerous studies have shown that patient harm has been and remains an endemic iatrogenic consequence of the life *and death* of a patient in the hospital setting.

The 1992 Quality in Australian Healthcare Study examined a random sample of 14,179 admissions across 28 hospitals in two states of Australia and identified 112 deaths (0.79%). Nearly 70% of the deaths, and 58% of the cases of significant disability were considered to have a high degree of preventability (Wilson et al., 1995).

In the UK, 100 sequential admissions to the intensive care unit (ICU) from ward areas across 2 hospitals found that 54 had sub-optimal care on the ward prior to transfer. This group of patients had a mortality rate of 56%. Some of the sub optimal treatment factors included failure to seek advice, lack of knowledge, failure to appreciate clinical urgency and lack of supervision (McQuillan et al., 1998).

In a Melbourne (Australia) teaching hospital it was found that the median period of time that clinical instability was documented was 6.5 hours (range 0-432 h) prior to either cardiac arrest call or intensive care unit referral among 122 in-hospital patients. Yet many of these patients were reviewed, on average, twice by junior medical staff during the intervening period (M. D. Buist et al., 1999).

Finally, others have found that patients who have just one episode of single-parameter vital-sign abnormality during hospitalization had a higher 30-day mortality rate (25%) as compared to patients who did not (3.5%) (Bell, Konrad, Granath, Ekbom, & Martling, 2006).

Despite many studies examining the antecedents of patient deterioration and death in the hospital setting, it remains difficult to determine which vital-sign parameters and which threshold values can reliably predict dangerous deterioration before it happens.

Kause et al (2004) studied “primary events” across 68 hospitals over 4 days in UK, Australia and New Zealand. A primary event was defined as a cardiac arrest, death or ICU admission. Of the 638 primary events, 383 (60%) had antecedent factors of systolic blood pressure less than 90 mmHg (148), Glasgow coma score (GCS) drop > 2 points (118), threatened airway (75), respiratory rate > 36 (54), pulse rate > 140 (45) (Kause et al., 2004). While Buist and others, showed in a study of 6,303 patients 1,598 experienced abnormal observations and 146 died. The two most common abnormal observations were hypoxia < 90% (51%) and hypotension (17%). Significant predictors of death were: respiratory rate <6 or >30/min, oxygen saturation <90%, hypotension, decreased or loss of consciousness. Any one of these 6 events resulted in a six-fold increase in mortality (M. Buist, Bernard, Nguyen, Moore, & Anderson, 2004).

Objective written parameters appear to be favoured over open-ended clinician judgment call alone and DeVita et al. (2006; 2010) recommend predefined numeric trigger thresholds for HR, RR, BP and $SpO_{2.}$

Case study: The nurse in charge reviews the patient, noticed the GCS has decline, although other vital sings remain stable. She calls the doctor in charge, but the doctor is currently performing a procedure and is unavailable to see the patient. Just a resident is available.

The patient is presenting another antecedent factor of clinical deterioration.

The Rapid Response System Closed Feedback Loop Model

Figure1 provides a flow diagram of the common sequence of events that ought to track and trigger a rapid response to a deteriorating patient.

There are two key systems in most closed loop models such as this: Afferent Limb (receiving pathway) and Efferent Limb (action pathway). Our diagram shows a continuous feedback loop with 4 linked and critical components in each.

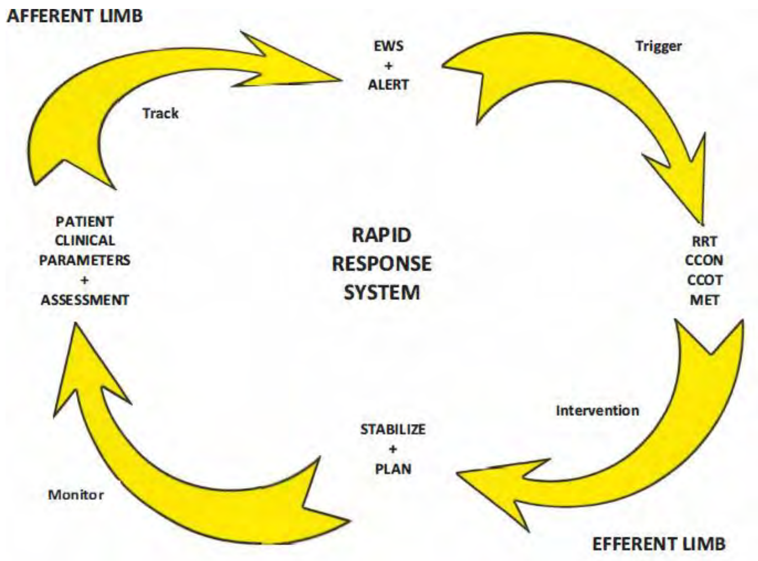

Figure 1

The Afferent Limb describes

1. Patient assessment and monitoring of vital parameters.
2. Tracking of vital parameters to detect abnormality or deterioration
3. Early Warning Score and Alert flags deterioration and indicates the need for action
4. Trigger, being a prescribed action response to the detection of deterioration.

The Efferent Limb describes:

1. Rapid Response Person/Team is mobilised to attend the patient bed side

2. Intervention – The RRT is sufficiently skilled to intervene in an emergency and to engage whatever other expertise is required to correct the deterioration.
3. Stabilise and Plan. The whole team review the goals of care and specific follow up actions required.
4. Monitor. Continue to monitor closely to avert any relapse of deterioration.

The Afferent Limb of RRS

The afferent limb commences with regular vital sign and other **patient parameter observations and assessment** at the bedside. Such observations need to be purposeful, thorough and made by a health professional suitably trained and cognisant of the significance of any subtle deterioration in the patient's condition and knowledgeable of the approved protocol driven response required should an aberrant finding or deterioration be detected. This is sometimes known as "tracking". "**Tracking**" is the process of monitoring and recording patient clinical status over time and looking for abnormalities and signs of deterioration. The most common vital signs "tracked" in early warning systems are HR, RR, BP, SpO_2, Temperature, conscious level and "worried" (see Figure 2)

Figure 2: Single parameter track and trigger chart to alert Medical Emergency Team (Maroondah Hospital, Australia, 2006).

MET Call Parameters = Call 555

Airway:

Threatened

Breathing:

Respiratory Rate 8< and > 30

SpO2 < 92% (on or off Oxygen)

Circulation:

Heart Rate <50 and >120/min

Systolic BP <90 and >180 mmHg

Neurological:

Seizure or fall in GCS >2 points

Other:

Worried about patient

Parent Unit cannot attend

Urine output <30ml/hour (for 2 hours)

>500 ml/hour (for 2 hours)

Blood Glucose Level <3.0 and >20 mmol/L

Temperature < 35 and >39.5oC

Metabolic derangement

Early Warning Score (EWS) systems and Alerts have been in place for over 2 decades and were designed to inform when a Medical Emergency Team should be summonsed (Lee, Bishop, Hillman, & Daffurn, 1995). The earliest published EWS systems identified the specific vital signs to be “tracked” (observed/recorded) and the parameters considered to be abnormal and therefore requiring a “trigger” (response/action) were clearly identified (Daffurn, Lee, Hillman, Bishop, & Bauman, 1994).

These days, there are essentially 3 types of EWS methods used to alert clinicians to a concern requiring action in hospital settings:

- Single parameter thresholds: These are a set of specific parameters that, if the identified threshold is exceeded, will stimulate a trigger (see Figure 2). The trigger is usually the escalation and summonsing of more experienced or knowledgeable assistance to the bedside.
- Multi-parameter score: This method provides an attribution of points for each abnormal parameter and a cumulative score is attained commonly known as an Early Warning Score (EWS). An EWS above a prescribed threshold will provide an alert that then requires an action by the patient's nurse to "trigger" a set of similar escalations and help as above (See Figure 3a).
- Mixed method trigger: Over time single and multi-parameter methods have become merged into scoring systems that trigger for either a single aberrant measure or a total score that exceeds the acceptable "safe" zone (Figure 3b).
- **Figure 3a:**
- **Early warning Scoring System – aligning aberrant parameter readings with a numeric score (Royal College of Physicians).**

National Early Warning Score (NEWS)*

PHYSIOLOGICAL PARAMETERS	3	2	1	0	1	2	3
Respiration Rate	≤8		9 - 11	12 - 20		21 - 24	≥25
Oxygen Saturations	≤91	92 - 93	94 - 95	≥96			
Any Supplemental Oxygen		Yes		No			
Temperature	≤35.0		35.1 - 36.0	36.1 - 38.0	38.1 - 39.0	≥39.1	
Systolic BP	≤90	91 - 100	101 - 110	111 - 219			≥220
Heart Rate	≤40		41 - 50	51 - 90	91 - 110	111 - 130	≥131
Level of Consciousness				A			V, P, or U

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- **Figure 3b: Early Warning Scoring System – Each clinical risk level will have a specific action required to be followed by the bedside clinician tracking the patients progress. (Royal College of Physicians).**

NEW scores	Clinical risk
0	Low
Aggregate 1–4	
RED score* (Individual parameter scoring 3)	Medium
Aggregate 5–6	
Aggregate 7 or more	High

-
- THE NEWS TRIGGER SYSTEM ALIGNED TO THE SCALE OF THE CLINICAL RISK
- A low score (NEW score 1-4) should prompt assessment by a competent registered nurse who should decide if a change of frequency of clinical monitoring or an escalation of clinical risk is indicated
- A medium score (NEW score 5-6 or a RED score) should prompt an urgent review by a clinician skilled in the assessment of acute illness, who will consider if there should be an escalation of care
- A high score (NEW score of 7 or more) should prompt emergency referral to secondary care
- *RED score refers to an extreme variation in a single physiological parameter (i.e. a score of 3 on the NEWS chart, coloured RED to aid identification and represents an extreme variation in a single physiological parameter).

Paper based observation charts such as the Adult Deterioration and Detection System (ADDS) (Elliott et al., 2014) are colour coded to track the patient's vital signs and provide visual alert that the measured parameter is in a "coloured zone". In the development of ADDS colour coded charts heuristic evaluation and human factors principles were used to maximise the track and trigger response of clinicians using the tool. The coloured zones provide a visual alert cue to the clinician that the patient's measured clinical parameter is now in a zone that requires special consideration or a specific clinical response. The response required can be related to a single significant vital sign entering the red zone or if the cumulative score of more than one aberrant vital signs exceed the threshold of normality (Figure 4).

More contemporary EWS systems are now fully automated and embedded into the electronic medical record (EMR - described later in the Future Directions section).

Clinical Staff Education and Training in Track and Trigger EWS Procedures

Critical to the effective utilisation of the track and trigger systems is the education, training, and confidence of the nurses at the ward level to use and respond appropriately to the tool and the activation of the escalation protocol. Historically this has been a significant issue stimulating the development and need for MET and other RRSs (Daffurn et al., 1994).

In a descriptive study of 32 ward nurses, Jane Cioffi (2000) identified that many nurses lacked the confidence to summons help for their patients when required. The summons for help was delayed because the nurses feared they would "feel like an idiot if they called unnecessarily", or they would consult a colleague first before making the call. They also noted that the junior doctors were often just as unsure of themselves in these situations as the nurses. Similar findings have been described by Jones et al (2006) who described how nurses would follow traditional hierarchical reporting lines to the parent medical service rather than be subjected to criticism by their medical colleagues. Buist (1999) has also discussed similar behaviour by junior doctors.

The first step in establishing an appropriate track and trigger process is to educate the staff in the use of the tools and protocols and to be confident to activate the response. The hospital management also need to provide education and training for the response team and to give them capacity to spend time with the patient and staff so that thorough assessment, intervention and follow up education and documentation activities can be accomplished. Education and counselling of the ward staff is critical, and careful use of language is also important so that the "trigger" nurse is NOT left to "feel like an idiot" – public praise and acknowledgement for having the courage to trigger and escalate the issue is critical to encourage others to do likewise. However if the trigger has been delayed or was unnecessarily premature, the response team need to use this as a "teachable moment", to help the ward staff understand and "fill" the knowledge gaps they may have.

In addition to educating the staff in this process it is also important that the organisation sanctions the response mechanism and audits the system to ensure that the trigger is escalated in an appropriate and timely manner and that outcome measures are monitored to ensure the effectiveness of the RRS and the staff teams involved.

Efficiency and Effectiveness Measures

The ideal measures to have in place to monitor the efficiency and effectiveness of the RRS will encompass demographic, process, output and outcome measures. All of which are necessary to ensure the system is functioning to achieve best possible outcomes and to ensure continuous improvement over time (Figure 5).

Figure 5: Minimum data set used to evaluate RRS

Demographics:

Patient Age, gender, location, admission diagnosis

Event day, time, location

Composition of response team

Process measures:

Rescue response time -Time of trigger to time of call

Rapid response time - Time of call to time of RRT arrival

RRT time on ward

Output measures:

Reason for call

Types of interventions rendered

Frequency of calls

Staff education/training

Ward staff evaluation of response team actions

Response team evaluation of ward staff response

Outcome measures

Admission to ICU or other higher acuity area

NFR order

Death

Figure 4: Example of an Adult Deterioration Detection Chart.

Observation chart for the National Early Warning Score (NEWS)

NEWS KEY: 0 | 1 | 2 | 3

NAME: | D.O.B. | ADMISSION DATE:

	DATE		DATE
	TIME		TIME
RESP. RATE	≥25	3	≥25
	21-24	2	21-24
	12-20		12-20
	9-11	1	9-11
	≤8	3	≤8
SpO_2	≥96		≥96
	94-95	1	94-95
	92-93	2	92-93
	≤91	3	≤91
Inspired O_2%	%	2	%
TEMP	≥39°	2	≥39°
	38°	1	38°
	37°		37°
	36°	1	36°
	≤35°	3	≤35°
BLOOD PRESSURE (NEW SCORE uses Systolic BP)	230	3	230
	220		220
	210		210
	200		200
	190		190
	180		180
	170		170
	160		160
	150		150
	140		140
	130		130
	120		120
	110	1	110
	100	2	100
	90	3	90
	80		80
	70		70
	60		60
	50		50
HEART RATE	>140	3	140
	130	2	130
	120		120
	110	1	110
	100		100
	90		90
	80		80
	70		70
	60		60
	50	1	50
	40	3	40
	30		30
Level of Consciousness	Alert		Alert
	V / P / U	3	V / P / U
	BLOOD SUGAR		Bl'd Sugar
TOTAL NEW SCORE			TOTAL SCORE
Additional Parameters	Pain Score		Pain Score
	Urine Output		Urine Output
	Monitoring Frequency		Monitor Freq
	Escalation Plan Y/N n/a		Escal Plan
	Initials		Initials

The ideal measurement system will be contained within an electronic system, ideally an EMR. It will have data populated automatically from the patient e-chart and will calculate measurement scores automatically. It will also have tick boxes and menu lists to ensure standardisation of language and data collation to reduce unnecessary clinician documentation time or research interpretation error.

Beadle (personal communication, August 2015) surveyed and interviewed 124 nurses following the introduction of an electronic patient record system that contain an automated EWS and alert function. Of the nurses that responded 92% preferred the electronic EWS system over the previous paper based version, 75% believed the electronic score were more accurate than written scores and 85% felt more empowered to follow the cascade call based on the electronic alerts than those that were on paper. Preliminary results are published online by Abu Dhabi Health Services Company (2015).

The Efferent Limb of RRS

Once a patient's vital signs have reached a prescribed parameter in the EWS, the bedside nurse is then alerted to action, triggering a sequence of prescribed responses along the efferent limb of the RRS closed loop feedback system (Figure 1).

Nursing Roles in Rapid Response Systems

The rapid response nurse (RRN) has many different names and slightly differing roles depending on the context and emphasis of the role and outcomes the position is designed to achieve. Some of the titles for this role in the literature include but are not limited to rapid response nurse, ICU liaison nurse, nurse-at-night, clinical team coordinator (CTC), Medical emergency team nurse (MET nurse) or critical care outreach nurse (CCON) to name a few. For ease of discussion we refer to all these as CCON, acknowledging that some variance does occur between some roles.

Characteristics of the CCON Role

The CCON role may do more than simply respond to MET codes or the deteriorating patient, in fact it is recommended that if the role of the CCON is available for very early intervention they can help to improve the assessment and management skills of ward nurses (Alberto et al., 2014; Eliott et al., 2012), intervene in a patient's care long before deterioration in the EWS occurs and potentially prevent unnecessary codes and death throughout the hospital. Williams et al (2012) describe a much broader range of potential tasks and activities for the CCON role in their study that have been summarised in Figure 6.

Figure 6: Core and extended potential scope of the CCON role (adapted from Williams 2012)

Core scope of the CCON role:

- Actively coordinates code blues (MET s) or EWS trigger as first responder

Extended potential scope of the CCON role:

Clinical assessment:

- Continuously monitors patients at risk
- Aids with patient flow activity
- Informs prioritization of clinical workloads of teams

Technical intervention:

- Aids with other hospital codes (violence, evacuation, etc)
- Assists staff manage difficult tasks eg. IV cannulation
- Advanced problem solving and troubleshooting of clinical issues
- Guidance on resource needs and management, eg. Borrowing scarce resources and equipment form other departments

Communication/interpersonal

- Facilitates dispute resolution
- Provides multidisciplinary leadership
- Formal report at the end of shift of those patients reviewed

Clinical Teaching

- Nursing and medical staff
- Impromptu teaching and support
- Competency training and assessment
- Uses every moment as a *teachable moment*

Critical to the success of these RRS programs is that the CCON demonstrates excellence in the following attributes:

- Clinical assessment,
- Technical intervention,
- Communication,
- Teaching

In addition, the CCON need to be familiar with the clinical and practice policies, procedures and protocols across many areas of the facility and have a reputation for being approachable, patient and responsive to the needs of both medical and nursing staff (Williams et al., 2012).

Case study: The CCON was rounding in the medical ward, when she sees a woman approaching the nurses' station. No nurses were present. The CCON asks the woman if she needs something. The woman answers that her husband became sleepy, suddenly less responsive; the nurse in charge had assessed him and said she would call the doctor.

The CCON approaches the patient, she realises the patient is bleeding and unconscious. She called an intensivist, initiated oxygen therapy, and increased IV fluids while she was requesting a medical history from the patient's wife, the nurse in charge and the resident. She orders arterial blood gases, Foley catheter and nasogastric tube insertion.

Critical Care Outreach Team (CCOT) Composition and Role

As with the CCON, we also find many differing terms and scope of the CCOT. Also known as the Medical Emergency Team (MET), Rapid Response Team (RRT) and Patient-at-Risk Team (PART), to name a few, the overriding common function of all is that it is a team of 2 or more individuals from the multidisciplinary team with complimentary advanced clinical skills.

The CCOT work collaboratively and cooperatively to assess, stabilise and plan the care of a patient at risk of further deterioration in the general ward setting. Generally the skill sets expected of the CCOT are summarised as follows:

- Management of Airway/breathing – medical officer with advanced airway management skills, usually an anaesthetist.
- Management of physiological deterioration – medical officer with broad critical care knowledge and skills, usually an intensivist.
- Advanced clinical nursing skills – CCON
- Additional support and assistance – ward medical and nursing staff

There remains debate regarding the appropriate composition of the CCOT. There are essential 2 models of CCOT/RRT/MET response, a "two tier" of "single tier" system.

- Two tier system – the first tier in the two tier system is a small team with either a CCON only or in combination with a medical physician that respond to a consultation request for guidance or advice: The threshold EWS or other parameters to engage the first tier team is generally much lower than the code blue-type call and generally requires a response within 15 minutes. The second tier is a larger multidisciplinary team who can fully respond to all codes including complex "code blue" scenarios.

- Single tier CCOT System – Some facilities consider that any call for assistance should have the same level of urgency and composition of RRT as the second tier team described above even if the requirement is for a situation less intense than a cardio-pulmonary arrest.

Proponents for the single tier model argue that the first tier in a two-tier system may be under staffed or under-skilled to respond to a rapidly deteriorating patient. However proponents of the two-tier system suggest that many situations picked up early will only require consultation, advice and guidance, therefore 1) the CCON and/or physician alone is accessible and sufficient in most instances, 2) a small response team is less intimidating to the ward staff (and especially ward nurses) to call for advice and evaluation and 3) it is less costly and disruptive to the system. Each organisation will need to assess and determine which system it will adopt and provide clear evidence and guidance to staff to inform the rationale for each choice.

Critical to the effectiveness of the CCOT are clear written protocols and algorithms that all members of the team are familiar with and competent to perform. Each member knows their specific component role and can implement their contribution competently, efficiently and effectively. In addition, each member is familiar with and knows the role, contribution and sequencing of the inputs of all other members of the team.... Similar to a well studied and rehearsed orchestra.

The other key element to the "orchestra" is the conductor! The lead, usually the intensivist, will only be as good as the musicians (other doctors and nurses) and if they all play well together the audience (patient) will applaud their performance… but hopefully not come back for an encore!!

Case study: When the intensivist arrives (15 mins after CCON call), the CCON and the resident had already informed the family about the current clinical situation and future actions. The intensivist reinforced this communication with patient's wife. The intensivist had already managed ICU bed availability for a potential admission. They meet the parent unit doctors and organize patient transfer to ICU.

In this case, the CCOT has two respondents, a CCON and an intensivist. Good communication with the parent unit staff is vital. In a further dialogue with the nurse in charge, she said she has recently started to work at this hospital, and that she was not familiar with the CCOT activities and activation criteria. CCON takes the opportunity to let the staff know about the criteria for triggering the CCOT.

Specific Variations to the Standard RRS

Paediatrics

Like adults, many Paediatric EWS (PEWS) have a degree of variability suggesting a limitation of evidence and confidence to be precise as to the right track and trigger scores and systems to use for this population group. Many more sophisticated PEWS tools provide age-specific parameters for children 0-1year, 1-4, 5-11, 12+. As with adult systems the key measures include threatened airway, hypoxemia, tachypnea, tachy/bradycardia, temperature, hypotension, acute changes in neurological condition, cardiac and respiratory arrest and of course "worried" (Monaghan, 2005; Tibballs & Kinney, 2009).

However a relatively new trend in paediatric medicine, which is also being adopted in some countries, is the ability for the parents/family to be able to activate the response team directly or via a central call number. This model is particularly strong in Australia (Queensland Health, 2014) and is receiving international media and parental advocacy elsewhere (Bedo, 2015).

PEWS and paediatric RRS show similar benefits to those published regarding adult RRS. Tibbals & Kinney (2009) studied the impact of a paediatric MET system over 4 years and found a 55% reduction in preventable cardiac arrest, and that 53% of 809 calls did not result in an ICU admission. Whilst one interpretation of this result is that the MET was being over utilised, the authors also acknowledge that high levels of suspicion and early intervention may result in a situation where it is better to be sure than sorry!!

The major and obvious difference between adult and paediatric RRS is the skill and expertise of the paediatric RRT who must be experts in paediatric acute care assessment and treatment.

Obstetrics

Obstetric RRS are essentially similar to adult RRS with two major exceptions, 1. Blood pressure parameters of a MOEWS (Modified Obstetric Early Warning Score) are more conservative: Normal acceptable SBP = 110-149 and DBP <90 mmHg, and 2. The CCOT generally adds or substitutes an intensivist with an Obstetrician. The CCON is often a nurse with midwifery qualifications and skills, although if they are a “purest ICU nurse” then it is expected that the midwives on the floor will provide the additional midwifery-specific knowledge and skills required in most scenarios.

As with Adult RRS programs, MOEWS rely heavily on team training and competency development in advanced life support obstetric (ALSO) emergencies. Draycott et al. (2006) have shown that training in obstetric emergencies can lead to substantial improvements in hypoxic ischemic encephalopathy, 5-min APGAR scores <7 and shoulder dystocia management.

The “Administrative Limb” - RRS governance

An often forgotten yet vital component to the introduction and maintenance of RRSs is the governance and management of such an intervention. The RRS is a hospital-wide, multi-disciplinary clinical and system improvement policy direction designed to impact the overall capacity to save and rescue patients in most clinical settings. Contemporary hospitals are measured on their performance against important patient safety and outcome measures such as standardised mortality ratios, unplanned admission to ICU, unexpected death, sepsis and the like and RRS can help to improve such outcomes. Furthermore the RRS is an expensive investment and therefore requires senior oversight and attention to ensure the investment actually meets the goals expected of it.

Our experience suggests that the RRS steering committee ought to be a high-level clinical quality and safety committee that reports directly to the executive or through the hospital's morbidity and mortality committee or resuscitation committee.

At least in the initial years of establishing the RRS program the following key members ought to be on this committee.

- Chief Medical Officer
- Chief Nursing officer
- ICU medical lead
- ICU nursing lead
- CCON representative
- General medicine lead
- Charge Nurse representative
- Data analyst.

The role of the committee is to enable successful change and improvement in clinical systems by ensuring the four key elements of empowerment are provided: Direction, Knowledge, Resources and Support. The need for high-level executive representation and commitment cannot be overstated. Our experience suggests that one of the key differences between those hospitals who can successfully implement RRS and those that cannot, is that the unsuccessful teams have not been able to engage or recruit the commitment of the senior executive to invest in the program.

Case study: *The CCON informs CCOT administration board about the case. They decide to review the procedures and policies for providing education/information to newly admitted staff.*

Future Directions

As mentioned earlier, the use of EMR to auto-calculate EWS, provide immediate alerts and protocol driven guidance to the bedside clinicians as well as directly alert the RRT electronically are the newer technological improvements we are now experiencing in the journey towards continual improvement of the RRS.

On the human side, RRS responders are now becoming “super-specialist”, designated senior clinical nurses who are recruited into seemingly prestigious and recognised CCON roles (various titles!). With greater specialisation it is foreseeable that these nurses will lead further research and refinement of methods and practices with expanding skill expectations and scope of clinical practice, which will inevitably lead to further education, training and potentially clinical privileging requirements to ensure optimal practice and safety.

The movement towards patient and family advocacy and empowerment in health care will ensure stronger representation of patients, carers and family members on to health care safety and quality governing committees and groups. They are likely to demand greater immediate access to RRS and the ability to initiate such responses directly as we have already seen in countries such as Australia.

Finally, the world witnessed the formation of the International Society of Rapid Response Systems in May 2014 (http://rapidresponsesystems.org/?page_id=33). A truly global and multidisciplinary organisation with membership categories for doctors, nurses, allied health practitioners, managers and administrators and lay persons. It is envisaged that national and regional RRS organisations will form or will increasingly be represented through subcommittees of existing national critical care associations.

Conclusion

CCONs are a clinical resource and support for at risk or deteriorating patients, their families and staff. They are a key component of rapid response systems. RRS is a systematic approach for responding and managing clinical deterioration hospital wide.. Hippocrates instructed us: *primum nil nocere* (First, do no harm). Unfortunately Hippocrates naively thought we would all follow his doctrine. Wrong! What Hippocrates failed to say was: "*Should you do harm, then put in place a rapid response system to correct your error"*…some 2500 years later we can only hope Hippocrates is happy with our progress so far!!

Questions

1. Name the eight of most common signs used to track and trigger a rapid response to a deteriorating patient?

2. According to Bell et al what is the 30-day mortality rate of hospitalized patients who had single-parameter vital sign change?

   A. 3%, B. 10%, C. 20%, D. 25%

3. Describe the key components of the Afferent and Efferent arm of the RRS.

4. What is meant by “Tracking”?

5. There are essentially 3 types of EWS methods used to alert clinicians to a notifiable level of concern requiring action in hospital settings, which of the following is NOT one of them?

   Answer:

   A. A. Single parameter thresholds:

   B. Multi-parameter score.

   C. Mixed method trigger.

   D. Closed feedback loop model

6. Jane Cioffo’s study of 32 nurses, one of the significant reasons nurses did NOT call for help in a timely manner was because

   Answer:

   A. They could not tell the time.

   B. They were too busy and could not manage any greater workload.

   C. They would “feel like an idiot if they called unnecessarily”.

   D. Doctors are not capable of responding in time.

7. Identify three process measures that may be used to evaluate the effectiveness of the RRS.
8. Beadle et al (2015) surveyed and interviewed 124 nurses following the introduction of an electronic patient record system that contain an automated EWS and alert function. Of the nurses that responded what percentage preferred the electronic EWS system over the previous paper based version?
   A. Only experienced nurses,
   B. B. 92%,
   C. C. 62%
   D. D. Only novice nurses
9. Which of the following is NOT normally considered a clinical assessment role of the CCON:
   A. Continuously monitors patients at risk
   B. Aids with patient flow activity
   C. Informs prioritization of clinical workloads of teams
   D. Prescribes a Do Not Resuscitate order after consultation with the patient.
10. Generally the skill sets expected of the Critical Care Outreach Team are summarised as follows, except:
    A. Airway/breathing management – medical officer with advanced airway management skills, usually an anaesthetist.
    B. Management of physiological deterioration – medical officer with broad critical care knowledge and skills, usually and intensivist.
    C. Advanced clinical nursing skills – CCON
    D. Chief Finance Officer or delegate.

11. In the Tibbals and Kinney study the impact of a paediatric MET system over 4 years and found preventable cardiac arrest reduced by:

    A. 25%,

    B. 50%

    C. 75%,

    D. Trick question, it increased!

12. Name two significant differences found in an Obstetric RRS (MOEWS) and a regular adult RRS.

13.

    There are four key elements of empowerment identified in this article, they are

    A. Election, Influence, Resources and Sustainability

    B. Direction, Knowledge, Political savvy and Resilence

    C. Direction, Knowledge, Resources and Support

    D. Direction, Kindness, Reason and Support

Answers

1. 1) Threatened airway 2) Respiratory rate change 3) Oxygen saturation level change, 4) Heart rate change, 5) Blood pressure change, 6) Temperature change, 7) Neurological/conscious level change, 8) “worried”

2. D

3. The Afferent Limb describes

- Patient assessment.

- Tracking of vital parameters.

- Early Warning Score and Alert

- Trigger

The Efferent Limb describes:

- Rapid Response Person/Team

- Intervention.

- Stabilise and Plan.

- Monitor.

4. Tracking is the process of monitoring and recording patient clinical status over time and looking for abnormalities and signs of deterioration.

5. D

6. C

7. **Process measures:**

- Rescue response time -Time of trigger to time of call

- Rapid response time - Time of call to time of RRT arrival

- RRT time on ward

8. B

9. D

10. D

11. B

12. (1)The blood pressure parameters of a MOEWS (Modified Obstetric Early Warning Score) are more conservative: Normal acceptable SBP = 110-149 and DBP <90 mmHg, and (2)The CCOT generally adds or substitutes an intensivist with an Obstetrician.

13. C. Direction, Knowledge, Resources and Support

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Chapter 6

Aggressive Management of Severe Traumatic Brain Injury

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Key words:

Brain trauma, secondary brain injury, intracranial pressure, osmotherapy, metabolic suppression, surveillance, neuroimaging, targeted temperature management, mechanism-based intervention.

LEARNING OUTCOMES: After completing this e-chapter you will be able to:

1. Review key concepts related to the physiology of intracranial hypertension
2. Discuss the classifications of traumatic brain injury (TBI)
3. Identify priorities in the critical care management following TBI
4. Distinguish primary brain injury from secondary brain injury
5. Explain the nurses role in coordinating intracranial pressure (ICP) monitoring with cerebral spinal fluid (CSF) drainage
6. Discuss the role of targeted temperature management protocols in brain trauma management.

Chapter overview:

This chapter differentiates brain trauma by etiology and type including blunt versus penetrating brain trauma as well as primary versus secondary brain injury. Clinical analysis and case study explore intracranial pathophysiology, risk of secondary brain injury and modulating intracranial contents (brain, blood and CSF volumes) in critical care management of brain trauma as well as the role of temperature management in traumatic brain injury. Discussion examines cardiopulmonary physiology and multisystem consequences of injury on intracranial physiology, ICP control and recovery as well as implications for critical care nursing worldwide in the assessment and monitoring of patients.

Abstract:

Blunt or penetrating brain trauma alters intracranial physiology immediately as primary brain trauma. From that moment onward, intracranial pathophysiologic changes begin the cycle of secondary brain injury. Secondary injury evolves from consequences including brain edema, cerebral blood flow/blood volume alterations and/or changes in cerebrospinal fluid (CSF) hydrodynamics. Secondary injury may be consequent to global complications or multisystem trauma such as chest/abdominal trauma. Aggressive management of brain trauma must address intracranial consequences and include selective manipulation of brain tissue, blood and/or CSF volumes. Effective management must also account for multisystem dysfunction, oxygenation/ventilation and fluid/electrolyte balance because of the intimate relationships among cardiopulmonary and intracranial physiology. Multidisciplinary collaboration, the role of the intensive care unit (ICU) nurse in neurologic surveillance, rapid intervention and effective communication among all team members as well as meticulous attention to family needs and developing trust are vital aspects of overall care and optimal outcomes.

Introduction

Globally, traumatic brain injury (TBI) is a leading cause of death and disability in patients less than 45 years old, carrying with it a significant societal and personal burden (Decuypere & Klimo, 2012; Pangilinan, 2014). The overwhelming majority of patients following mild to moderate TBI have neurologic consequences 3 months post-injury with many requiring rehabilitation (Badgiata, Carney, & Crocco, 2007; Decuypere & Klimo, 2012; Pangilinan, 2014). Additional human costs include loss of employment, altered family dynamics, low self-esteem and lost potential. Severe TBI is defined as a Glasgow Coma Scale Score of 3-8/15 (Dawodu, 2015; Decuypere & Klimo, 2012; Haddad & Arabi, 2012). Mild TBI is defined by a GCS of 13-15 and moderate TBI is defined by a GCS of 9-12. ***Review of the GCS is found in table one*** (Dawodu, 2015; Decuypere & Klimo, 2012; Haddad & Arabi, 2012; Teasdale & Jennett, 1974). ***Comparison of mild, moderate and severe TBI is listed in table 2*** (Dawodu, 2015; Decuypere & Klimo, 2012; Haddad & Arabi, 2012). The purpose of this chapter is to review pathophysiology and aggressive management of TBI. Scope includes pathophysiology, clinical evaluation, neurodiagnostics and monitoring as well as clinical management and nursing care implications. Optimal patient and family care is illustrated by case study.

Physiology of Intracranial Hypertension:

TBI affects all three components of the contents within the intracranial space. **ICP physiology is illustrated in figure 1.** Salient events in ICP elevation and onset/progression of secondary brain injury are alterations in the relative volume of these 3 components contained within the intracranial vault. Multiple interventions may modulate one or more components of intracranial pathophysiology. Osmotherapy with mannitol and/or hypertonic saline creates an osmotic gradient between edematous brain tissue and circulating blood volume, facilitating water movement out of swollen brain tissue. Increased brain blood volume may be modulated by titrating controlled ventilation and facilitating venous drainage from the head. Hydrocephalus may be modulated by ventricular drainage coordinated with ICP monitoring. Brain metabolic state and related ICP/blood flow elevations may be modulated by drug therapies such as barbiturates or propofol. Therapeutic hypothermia, though controversial, may be utilized on a case-by-case basis to modulate brain metabolism, blood flow and ICP. Aggressive normothermia protects the brain from consequences of fever and may prevent ICP elevations consequent to increased cerebral blood flow and hypermetabolic state. Decompressive hemicraniectomy may be used on a case-by-case basis for refractory ICP elevations pending resolution of severe brain edema.

Sedation may decrease anxiety and brain arousal. Analgesia may decrease response to pain and brain arousal. Brain arousal may increase cerebral blood flow and complicate ICP control. Neuromuscular blockade (NMB) can be used to decrease global metabolic load by skeletal muscle paralysis as well as eliminate patient-ventilator dyssynchrony and coughing, both of which elevate intrathoracic pressure and ICP. The overall plan of care for TBI must also include avoiding hypoxemia, electrolyte/acid-base imbalances and preventing ICP progression to brain herniation syndromes. Terminal brainstem herniation is an end-stage and fatal outcome of refractory ICP elevations.

TBI Pathophysiology and trajectory

One classification of TBI is closed head injury where the brain is injured from trauma to the skull or a sudden, severe force applied to the skull causing brain trauma from hard contact against the inner table of the skull (Dawodu, 2015; Decuypere & Klimo, 2012; Ling & Marshall, 2008; L Rangel-Castilla, 2014). ***Figure 2 illustrates examples of closed head injury versus penetrating brain injury.*** A second classification is penetrating brain trauma, injury resulting from a projectile or sharp object (generally) penetrating the scalp, cranial vault, meninges and brain tissue itself, exposing the intracranial cavity to the environment (Griffin & Hickey, 2012; Santiago, Oh, Dash, Holcomb, & Wade, 2012).

TBI further differentiates between primary and secondary brain injury (Chen et al., 2008; Dawodu, 2015; Greve & Zink, 2009; Haddad & Arabi, 2012; Ling & Marshall, 2008; L Rangel-Castilla, 2014; Sahuquillo & Vilalta, 2007; Werner & Engelhard, 2007). Primary, at the moment of injury, occurs consequent to depressed skull fracture, closed head injury, penetrating brain trauma, subdural/epidural hematoma and/or traumatic intracerebral hemorrhage as well as brain contusion or laceration (Dawodu, 2015; Greve & Zink, 2009; Ling & Marshall, 2008; Pangilinan, 2014; L Rangel-Castilla, 2014; Santiago et al., 2012; Werner & Engelhard, 2007). Diffuse injury may be consequent to rapid acceleration/deceleration leading to diffuse axonal injury and/or brain edema (Dawodu, 2015; Pangilinan, 2014; L Rangel-Castilla, 2014; Werner & Engelhard, 2007). Secondary injury follows the immediate trauma and includes tissue ischemia, auto-regulatory failure, anaerobic metabolism, increased tissue lactate, cellular energy failure, release of excitatory amino acids and loss of cell membrane integrity (Greve & Zink, 2009; Ling & Marshall, 2008; L Rangel-Castilla, 2014; Sahuquillo & Vilalta, 2007; Werner & Engelhard, 2007). Loss of membrane integrity allows sodium and calcium influx into the cells, lipid peroxidation and loss of structural integrity, allowing cellular/tissue water influx resulting in further brain edema (Dawodu, 2015; Greve & Zink, 2009; Ling & Marshall, 2008; Pangilinan, 2014; L Rangel-Castilla, 2014; Sahuquillo & Vilalta, 2007; Werner & Engelhard, 2007). Loss of membrane integrity activates the coagulation cascade risking small-vessel clot formation and brain ischemia (Chodobski, Zink, & Szmydynger-Chodobska, 2011).

TBI Case study: Initial injury and presentation

A 21-year-old white female was found unconscious outside late at night. Emergency medical system (EMS) was activated and she was transported to the emergency department (ED) of a large regional trauma center. She had apparently fallen and sustained traumatic brain injury, multiple skull fractures and multisystem trauma. During transport, full cervical-spine precautions, intravenous (IV) access and ventilation support were initiated. Upon ED arrival, airway, breathing and circulation (ABC's) were prioritized. Controlled ventilation was maintained through an oral endotracheal tube. Early airway management and controlled ventilation is vital to avoid hypoxemia, hypercarbia and slow progression of secondary brain injury (Harris, Davenport, Hurst, & Jones, 2012). She was initially hypotensive and tachycardic. Multiple large-bore peripheral IV accesses were inserted for administration of crystalloid, medications and blood products. The patient had a GCS of 4/15, indicating severe TBI. Following volume resuscitation, her blood pressure was stabilized, ventilation was controlled and she was transported for emergent head CT for evaluation of intracranial injury. **Figure 3** illustrates head CT obtained immediately following admission and stabilization in the ED. Clinical neurological examination is the standard for evaluation of the potentially injured brain. With severely depressed consciousness, immediate evaluation for structural brain injury by obtaining stat head CT is paramount (Schimpf, 2012; Tsang & Whitfield, 2012).

Following heat CT results as noted, the patient was hyperventilated in the short-term pending and during transport to the operating room (OR) for neurosurgical intervention to modulate presumed severe ICP elevations. Hyperventilation ($PaCO_2$ below 35 mm Hg) can result in brain ischemia, increased morbidity and mortality. Hyperventilation is appropriate for the shortest duration possible pending definitive intervention (Brain Trauma Foundation et al., 2007j). Operative intervention included aggressive craniotomy/craniectomy with evacuation of subdural hematoma and insertion of a ventricular drainage catheter incorporating a fiberoptic transducer for ICP measurement. Immediate postoperative CT and appearance of ICP monitor/drainage insertion site are found in **Figure 4.**

TBI case study: ICU management in immediate postoperative phase.

Upon ICU arrival post-craniotomy and ICP monitor/drain placement, the patient received fentanyl and propofol for analgesia and sedation, to decrease cerebral responses to stimulation and treat pain. Neuromuscular blockade was initiated to promote synchrony with controlled ventilation, preventing surges in intrathoracic pressure consequent to cough responses and patient/ventilator dys-synchrony. She was managed with hyperosmolar therapy. Mannitol was titrated to a serum osmolality of 315-320 mOsm/L and she received hypertonic saline (3%) by continuous infusion. Her controlled ventilation was titrated to maintain normocarbia ($PaCO_2$ approximately 35-40 mm Hg). Ventilator-associated pneumonia (VAP) protocol was in place.

Critical Care Management Following TBI:

Postoperative critical-care management is guided as goal-directed therapy based on ICP monitoring and clinical/neurological assessment data. ICP monitoring may be effectively done by means of an intraventricular catheter, enabling CSF drainage and providing excellent ICP waveforms facilitating ICP pulse wave analysis and assessment of intracranial compliance. Other ICP monitoring options include fiberoptic catheters within the brain parenchyma or incorporated within ventricular catheter placement. Goal-directed therapies include metabolic suppression, sedation/analgesia, neuromuscular blockade (NMB), osmotic diuresis, titration of controlled ventilation as well as targeted temperature management and therapeutic hypothermia in select cases. Each therapy has specific implications for nursing care, and while variations in resources exist internationally priority areas for nursing care include focused monitoring and reporting of neurological changes and administration of indicated therapies per country specific, national, or international guidelines.

ICP monitoring and waveform analysis

Secondary brain injury may be a direct consequence of intracranial hypertension. ICP and cerebral perfusion pressure (CPP) are immediate priorities as appropriate following TBI (Arbour, 2004; Vender, Waller, Dhandapani, & McDonnell, 2011). ICP monitoring is paramount in a patient with GCS 3-8 and abnormal head CT. ICP monitoring may be appropriate in TBI in a patient with a normal head CT if two of the following are present: age greater than 40 years, decorticate or decerebrate posturing and hypotension (Arbour, 2004; Brain Trauma Foundation et al., 2007j). ICP monitoring in context with clinical evaluation, neuroimaging and goal-directed management significantly improves outcome (Feyen, Sener, Jorens, Menovsky, & Maas, 2012). For more benefit versus risk in clinical application, ICP monitoring devices used, should be easy to use, accurate, interpreted within clinical context, rapidly acted upon in a reproducible manner and guide therapy (Mendelson et al., 2012; Schimpf, 2012).

The most commonly utilized options for ICP monitoring include ventriculostomy and intraparenchymal device placement (Brain Trauma Foundation et al., 2007d; Vender et al., 2011). Ventriculostomy placement is considered the reference standard for ICP monitoring, giving good quality ICP waveforms and accurate, reproducible pressure measurements (Arbour, 2004; Brain Trauma Foundation et al., 2007d; Feyen et al., 2012; Schimpf, 2012). Ventriculostomy placement allows for CSF drainage as part of mechanism-based care and coordinated for managing intracranial hypertension (Arbour, 2004; Brain Trauma Foundation et al., 2007e; Mendelson et al., 2012; Schimpf, 2012; Vender et al., 2011). ICP treatment threshold is generally 20 mm Hg (Brain Trauma Foundation et al., 2007f; Schimpf, 2012).

Monitoring cerebral perfusion pressure (CPP) is also integral in managing severe TBI. CPP is determined by the following formula: CPP = mean arterial pressure (MAP) – ICP (Arbour, 2004; Feyen et al., 2012; Schimpf, 2012). Optimal monitoring of ICP and MAP are vital in managing severe TBI due to risks of hyperemia versus oligemia. Hyperemia consequent to hypertension may result in cerebral blood flow (CBF) surges and ICP elevation. Oligemic CBF states consequent to hypotension may result in brain ischemia. One management guideline includes a general CPP range of 50-70 mm Hg (Brain Trauma Foundation et al., 2007c). Other authors advocate goal-directed therapy for CPP between 60-75 mm Hg (Schimpf, 2012). CPP and ICP should be very closely monitored. For example, with CPP trending lower than 60 mm Hg, identifying possible causes and intervening appropriately intervention are vital. Management may be 2-fold and be directed toward ICP reduction as well as directed towards supporting blood pressure by administering crystalloid, blood products or vasoactive versus inotropic agents.

Additional information is obtained by detailed analysis of the ICP pulse waveform, waveform changes over time and in response to stimulation. Pulse waveform amplitude reflects changes in CBF consequent to the cardiac cycle, cerebrovascular compliance and reactivity. While requiring additional validation, this may be an additional approach to monitoring and yield further, actionable information from ICP pulse waveforms and concurrent MAP (Aries et al., 2012). Additional directions for research include analysis of complexity and responsiveness of ICP trends over time and in response to stimulation providing feedback on reactivity of brail blood flow. Initial studies suggest that more responsive and complex ICP is predictive of better outcome (Lu et al., 2012).

Close ICP waveform analysis indicating elevated P-2 component of ICP pulse waveform may also indicate compromised intracranial compliance and higher predictive value for more significant ICP elevation in response to stimulation (Arbour, 2004). Stimulation may include airway manipulation/suctioning, repositioning or invasive procedures such as peripheral venipuncture or thoracostomy. ***Figure 5 illustrates ICP pulse waveforms as exemplars, indicating degree of compliance at baseline and relationship between degree of intracranial compliance and ICP elevation in response to stimulation.***

TBI case study: Coordinating ICP monitoring with CSF drainage:

Ventricular CSF drainage was utilized and coordinated with ICP monitoring. The ventriculostomy/transducer system was closed at intervals and CSF was to be drained if ICP remained above 20 mm Hg for greater than 5 minutes. ICP monitoring via ventriculostomy yielded good quality ICP waveforms and ability to assess intracranial compliance by waveform analysis and ICP responses to stimulation with time to resolution. The patient continued to receive mannitol for hyperosmolar therapy, sedation, analgesia and neuromuscular blockade. Protocol for prevention of ventilator-associated pneumonia (VAP) was in place.

Hyperosmolar therapy

Hyperosmolar therapy is among the mainstays of ICP control following brain trauma (Decuypere & Klimo, 2012). The two main options for hyperosmolar therapy are mannitol (considered first-line) and hypertonic saline (Brain Trauma Foundation et al., 2007a; Decuypere & Klimo, 2012; Griffin & Hickey, 2012; Haddad & Arabi, 2012; Helmy, Vizcaychipi, & Gupta, 2007; Honeybul, 2011; Ling & Marshall, 2008; Protheroe & Gwinnutt, 2011; Ropper, 2012). **Table three outlines specific agents utilized for hyperosmolar therapy and includes dosing, cardiovascular/clinical effects, goals of care and nursing considerations** (Brain Trauma Foundation et al., 2007a; Decuypere & Klimo, 2012; Griffin & Hickey, 2012; Haddad & Arabi, 2012; Helmy et al., 2007; Honeybul, 2011; Kerwin et al., 2009; Ling & Marshall, 2008; Oddo et al., 2009; Protheroe & Gwinnutt, 2011; Rockswold et al., 2009; Ropper, 2012; Sakellaridis et al., 2011).

Pulmonary management and severe traumatic brain injury

Pulmonary management following severe TBI is extremely challenging for multiple reasons. One reason is arterial CO_2 , which must be closely monitored and managed by frequent, close ventilator titration to avoid extremes of hyper versus hypo-capnia, avoiding cerebral blood flow extremes and decreasing risk of hyperemia versus ischemia. A second reason is optimal pulmonary care including head-of-bed (HOB) elevation and protocol-directed care to prevent ventilator-associated pneumonia (VAP). This includes frequent mouth care as well as deep airway suctioning. Mouth care and deep airway suctioning stimulate strong gag and cough reflexes, raising intrathoracic and intracranial pressures. A third reason is ventilator management in the setting of severe respiratory failure such as acute respiratory distress syndrome (ARDS) or concurrent chest/lung trauma. Maintaining oxygenation may require positive-end-expiratory-pressure (PEEP) and non-physiologic ventilation modes which, with elevated intrathoracic pressures, may make ICP more difficult to control. Maintaining oxygenation and tissue oxygen delivery is paramount in preventing secondary brain injury.

Titrating arterial carbon dioxide

While the use of hyperventilation may vary based on clinical guideline recommendations, it is usually reserved for emergent management of increased ICP unless there is the ability to monitor brain tissue oxygenation. Hyperventilation may be indicated for aggressive care immediately following TBI because aggressive hypocapnia in the short term (arterial CO_2 approximately 25 mm Hg), ICP can be rapidly reduced. Hypocapnia reduces ICP due to cerebral vasoconstriction, increasing risk of brain ischemia in a CBF state already likely compromised (Brain Trauma Foundation et al., 2007j; Decuypere & Klimo, 2012; Griffin & Hickey, 2012; L. Rangel-Castilla et al., 2010). Long-term hyperventilation is not recommended but may be effective in the short-term to control ICP elevations pending other definitive, mechanism-based therapeutics (Brain Trauma Foundation et al., 2007j; Decuypere & Klimo, 2012; Griffin & Hickey, 2012; Haddad & Arabi, 2012; Honeybul, 2011). If available, measures to monitor brain oxygen levels may be appropriate to titrate therapy (Brain Trauma Foundation et al., 2007j; Honeybul, 2011). Long-term ventilation should be titrated for a $PaCO_2$ approximately 35-40 mm Hg.

Pulmonary management and Traumatic Brain Injury

Integral to managing a patient following brain trauma is aggressive pulmonary care. This mandates meticulous attention maintaining airway patency, appropriate pulmonary hygiene and initiation/maintenance of VAP protocols. VAP protocols include mouth care at appropriate intervals, HOB elevation >/= 30 degrees and stress ulcer as well as deep vein thrombosis prophylaxis.[10] Due to possible risk of cough or gag-induced surges in ICP consequent to deep airway or pharyngeal suctioning, sedation/analgesia and neuromuscular blockade may be indicated to modulate risk of additional injury.

Ventilator management, respiratory failure and severe TBI.

Pulmonary complications following severe TBI may have multiple causes including pneumonia, concurrent pulmonary contusion or chest trauma, ALI/ARDS and pulmonary edema. In ALI/ARDS, lung recruitment maneuvers may be of particular concern with concurrent brain trauma with higher levels of PEEP and non-physiologic ventilation modes utilized (Lee & Rincon, 2012). Altered thoracic pressure dynamics may cause ICP elevations and mandate close attention of ventilator status and effects on ICP, MAP and CPP (Lee & Rincon, 2012; Zhang, Yang, Wang, & Fan, 2011). Close monitoring and incremental ventilator titration appropriate due to the individualized nature of ICP, MAP and CPP responses (Zhang et al., 2011).

Pain and Agitation Management in Severe TBI

Patient positioning, ventilation, airway suctioning, mouth care, concurrent injury and clinical states including drug/alcohol intoxication versus withdrawal may cause pain and agitation (Haddad & Arabi, 2012). Agitation and ventilator sys-synchrony can increase cerebral metabolic rate of oxygen ($CMRO_2$), ICP, blood pressure and systemic oxygen consumption, decreasing oxygen availability to brain tissue, risking secondary brain damage (Brain Trauma Foundation et al., 2007g). Clinically appropriate care for agitation must differentiate and address the cause. If agitation is due to alcohol withdrawal, replacement therapy with benzodiazepines may be effective. If agitation is due to pain, opioids such as fentanyl or morphine would be appropriate. If hypercarbia or progressive intracranial pathology is the cause, ventilation management or mechanism-based intervention for intracranial pathophysiology is most appropriate (Ling & Marshall, 2008).

Sedation/analgesia may decrease overall metabolic demand, $CMRO_2$, cortical arousal and patient/ventilator dys-synchrony, contributing factors to intracranial hypertension (Brain Trauma Foundation et al., 2007g; Griffin & Hickey, 2012; Helmy et al., 2007). While pharmacological agents vary internationally, midazolam is one commonly used short-acting benzodiazepine sedative/hypnotic which may also provide anti-convulsant effects. Short-acting opioids such as fentanyl citrate are appropriate, well-tolerated hemodynamically and have a shorter duration of action (Helmy et al., 2007; Ling & Marshall, 2008). Propofol may be superior as a sedative/hypnotic to benzodiazepines due to its more pronounced metabolic suppression and short, more predictable duration of action (Brain Trauma Foundation et al., 2007g; Griffin & Hickey, 2012; Haddad & Arabi, 2012; Helmy et al., 2007). Propofol has the potential risk of propofol infusion syndrome (PRIS), reported in patients following severe TBI, clinically associated with a pronounced inflammatory state. PRIS is characterized by a temporal relationship between hemodynamic instability and initiation or upward titration of propofol. Clinical findings of PRIS include significant hemodynamic instability, metabolic (lactic) acidosis, hyperkalemia, rhabdomyolysis and renal failure (Brain Trauma Foundation et al., 2007g; Diedrich & Brown, 2011; Griffin & Hickey, 2012; Haddad & Arabi, 2012; Helmy et al., 2007; Ilyas, Balacumaraswami, Palin, & Ratnatunga, 2009; Ling & Marshall, 2008; Zaccheo & Bucher, 2008). There are many superb references available addressing dosing, titration and coordinating bolus versus infusion dosing of sedation/analgesia following severe TBI (Brain Trauma Foundation et al., 2007g). Optimal care and best nursing practice mandates identifying the specific clinical state, utilizing appropriate drug classes, individualizing dosing and monitoring patient tolerance as well as vigilance for side effects.

Metabolic suppression following severe TBI.

Metabolic suppression therapy is utilized to control refractory ICP elevations. Barbiturate therapy, in a patient-specific, dose-related manner is utilized for this purpose. Agents utilized for this purpose include pentobarbital sodium. A listing of these agents including dosing, cardiovascular consequences, goals of care, clinical effects/side effects and nursing considerations is found in table 4, however it is acknowledged that pharmacologic therapy varies internationally (Brain Trauma Foundation et al., 2007g; Diedrich & Brown, 2011; Griffin & Hickey, 2012; Haddad & Arabi, 2012; Helmy et al., 2007; Ilyas et al., 2009; Ling & Marshall, 2008; Zaccheo & Bucher, 2008). **Figure 6** compares and contrasts normal EEG tracing with EEG tracing illustrating appropriate level of burst suppression (4-6 bursts/min or as directed per provider) during drug-induced coma for ICP control.

Temperature management following TBI

Aggressive temperature management may have two applications. One is maintaining normothermia. A second, on a case-by-case basis, therapeutic hypothermia. Hyperthermia or a febrile state is defined as an increase in core body temperature above 38.0^0C and in TBI may be consequent to thermoregulatory failure, such as direct damage to the hypothalamus, excessive vasoconstriction limiting heat loss to the environment, autonomic hyperactivity and increased sweating threshold (Sessler, 2009). Inflammatory response may also contribute to fever post-TBI. Fever increases neuronal hyperactivity, cerebral blood flow, oxygen consumption and ICP. Significantly, brain temperature may exceed core body temperature by as much as 2^0C (Badjatia, 2009; McIlvoy, 2012). Fever has a strong relationship with poor outcomes following TBI and should be aggressively treated and prevented when possible (Badjatia, 2009). Higher mortality, longer length-of-stay and greater disability are associated with fever post-TBI (McIlvoy, 2012).

Treatment options include pharmacological interventions such as acetaminophen and non-steroidal anti-inflammatory agents (Badjatia, 2009; Haddad & Arabi, 2012; Ling & Marshall, 2008; McIlvoy, 2012). Non-pharmacological interventions include surface cooling measures such as water-circulating cooling blankets/gel pads, intravascular cooling devices and ice-water application to skin as well as gastric lavage and IV infusion of chilled fluids (Badjatia, 2009; McIlvoy, 2012).

TBI Case study: Brain trauma and fever prevention.

Normothermia was maintained in this patient by use of water-circulating gel pads, decreased ambient room temperature and administration of acetaminophen. Increasing the temperature gradient between the patient and environment balanced heat production with heat loss and maintained normothermia. In the short-term, ICP reduction was maintained with the cooling device automatically adjusting water temperature based on core body temperature.

Figure 7 illustrates relationship between prevention of ICP elevations and aggressive fever prevention.

Therapeutic hypothermia and brain trauma.

Therapeutic hypothermia (TH) is a management option post-TBI on a case-by-case basis for refractory intracranial hypertension and is defined as controlled temperature depression to a range between 32.0^{0}C-35.0^{0}C (Decuypere & Klimo, 2012; Helmy et al., 2007; Rupich, 2009). Routine hypothermia following severe TBI is not supported by strong evidence (Brain Trauma Foundation et al., 2007b) In select circumstances of refractory intracranial hypertension TH has been demonstrated to reduce ICP, CBF and mortality/severe disability six months post-injury (Helmy et al., 2007; Kramer et al., 2012). Refractory ICP elevations post-TBI are associated with poor clinical/neurological outcomes and effective ICP control improves survival (Sadaka & Veremakis, 2012).

TH produces primary neuroprotection effects by decreasing $CMRO_2$, glucose utilization and lactate production. Brain oxygen consumption during TH may decrease between 5-7 % per 1^{0}C decrease in temperature (Faridar et al., 2011; Varon & Acosta, 2008). TH may also preserve high-energy phosphates, modulate gene expression, facilitate anti-inflammatory/anti-apoptotic pathways and significantly reduce ICP (Faridar et al., 2011; Jiang, 2009; Meyer et al., 2010; Rupich, 2009; Sadaka & Veremakis, 2012). In addition, TH may stabilize the blood-brain barrier, inhibit production of free radicals and reduce mobilization of excitatory neurotransmitters such as glutamate (Faridar et al., 2011; Jiang, 2009; Meyer et al., 2010; Rupich, 2009; Sadaka & Veremakis, 2012).

Methods of controlled reduction on body temperature are multiple and include internal and external cooling devices. TH may be produced by multiple techniques including by conduction with devices such as cool-water circulating blankets and gel pads applied to large skin surface areas have been utilized in addition to gastric lavage with iced water, ice-water application to skin, ice-pack applications and forced-air cooling devices (Faridar et al., 2011; Jiang, 2009; Meyer et al., 2010; Polderman & Herold, 2009; Varon & Acosta, 2008). Rapid IV infusion of chilled IV fluids such as normal saline at 3-4 degrees C has been utilized in hypothermia initiation (Jiang, 2009; Polderman & Herold, 2009; Varon & Acosta, 2008). Intravascular devices utilizing circulation of cold water through a catheter placed within a high-flow blood vessel such as the femoral vein have been utilized for rapid cooling (Polderman & Herold, 2009; Varon & Acosta, 2008).

TH has potentially harmful side effects and risks versus potential benefits must be analyzed. Side effects include shivering, which may increase metabolic rate and interfere with TH induction, hypokalemia, decreased drug metabolism/elimination, dysrhythmias, bradycardia, decreased cardiac output/hypotension, increased systemic vascular resistance (SVR), Q-T prolongation and hyperglycemia (Jiang, 2009; Polderman & Herold, 2009; Rupich, 2009; Sadaka & Veremakis, 2012; Varon & Acosta, 2008) Coagulopathy may occur secondary to effects on platelet count, platelet function and possibly dilutional coagulopathy consequent to crystalloid administration (Polderman & Herold, 2009; Sadaka & Veremakis, 2012; Varon & Acosta, 2008). Risk of pneumonia and wound infection is increased with TH. GI motility may be significantly impaired, impacting feeding protocols, wound healing, physiologic reserve, muscle wasting and recovery (Jiang, 2009; Polderman & Herold, 2009; Rupich, 2009; Sadaka & Veremakis, 2012; Varon & Acosta, 2008). Multiple aspects of TH in management of severe TBI remain to be refined by controlled study with larger sample sizes including timing, duration of therapy, best monitoring parameters and endpoints. Some patients may have maximal benefit with temperature reductions to 35-36^{0}C (Tokutomi et al., 2009).

Decompressive hemicraniectomy and timing in trajectory of care:

Intractable intracranial hypertension is one of the most dangerous secondary insults following severe TBI and a significant source of mortality and morbidity (Bao et al., 2010; Cianchi et al., 2012; Haddad & Arabi, 2012; Helmy et al., 2007). For refractory intracranial hypertension, progressive injury including terminal herniation can occur. Decompressive craniectomy (DC) as rescue for refractory, progressive intracranial hypertension is an option (Bao et al., 2010; Cianchi et al., 2012; Meyer et al., 2010; Olivecrona, Rodling-Wahlstrom, Naredi, & Koskinen, 2007). In DC a large area of the skull is surgically removed and the dura is opened which allows the brain to expand by increasing available space and controlling ICP (Bao et al., 2010; Cianchi et al., 2012; Haddad & Arabi, 2012; Helmy et al., 2007; Meyer et al., 2010; Olivecrona et al., 2007). Evidence is conflicting regarding survival and clinical outcomes following craniectomy (Cianchi et al., 2012; Cooper et al., 2011; Eberle et al., 2010; Olivecrona et al., 2007). DC in has also resulted in sustained improvement in brain oxygenation and decreased ischemic burden (Weiner et al., 2010). Timing and patient selection are significant. Patients with reactive pupils and without terminal brainstem dysfunction have more potential to benefit (Bao et al., 2010; Yatsushige et al., 2010). There are therapeutic risks and as with any invasive procedure, risk/benefit analysis must occur. Complications reported post-DC include brain herniation through the skull defect, subdural effusion, infection, brain contusion/hemorrhage at edge of craniectomy defect, hydrocephalus, seizures and ventricular enlargement (Honeybul, 2010; Honeybul & Ho, 2011; Stiver, 2009). Late complications may include cognitive dysfunction and failure of cranioplasty (Stiver, 2009). In the patient for this case study, immediate decompressive craniectomy was life-saving and clinically appropriate in her continuum of care from the initial ED management >>> CT scan >>> directly to OR and then followed by ICU admission for postoperative critical care management. She was young, had few comorbidities and still had neurological function at time of surgery.

Brain Tissue Oxygen Monitoring

All therapeutic interventions including osmotherapy, craniectomy and metabolic suppression as well as sedation/analgesia are goal-directed therapeutics to improve oxygen delivery and modulate the effects of ischemia at the tissue level. Mechanism-based modalities do effectively improve brain tissue oxygenation (Chen et al., 2008; Oddo et al., 2009; Pascual et al., 2011; Rockswold et al., 2009; Spiotta et al., 2010; Weiner et al., 2010).

Brain tissue oxygenation ($PbtO_2$) is measured following placement of a small oxygen-sensing probe into brain tissue. One device in common practice, the LICOX monitoring system (Integra Neurosciences, Plainsboro, New Jersey, USA) uses a small electrode with both temperature and oxygen sensing capability and is placed approximately 25-35 mm into white matter, usually the frontal lobe (Bader, 2006; Barazangi & Hemphill, 2008; Littlejohns, Bader, & March, 2003; Stewart et al., 2008). There are multiple outstanding references with additional technical detail on direct measurement of $PbtO_2$ including catheter placement, calibration and imaging (Bader, 2006; Barazangi & Hemphill, 2008; Littlejohns et al., 2003; Stewart et al., 2008). Comprehensive discussion of all these aspects is beyond the scope of this chapter. Clinical management of severe TBI using $PbtO_2$ –directed therapy is being increasingly used globally. $PbtO_2$ is the product of CBF, cerebral arteriovenous oxygen difference and is a focal measurement of tissue oxygenation (Haddad & Arabi, 2012). $PbtO_2$ values below 15-20 mm Hg may be considered a treatment threshold for goal-directed therapies to increase cerebral oxygen delivery (Bader, 2006; Haddad & Arabi, 2012; Littlejohns et al., 2003; Spiotta et al., 2010).

Systemic hypoxemia can reduce brain tissue oxygenation if oxygenation/ventilation needs are not met. Brain tissue oxygenation may be improved by titrating ventilation and/or inspired oxygen. Other interventions include administration of packed red blood cells (PRBC) to increase oxygen-carrying capacity; metabolic suppression to decrease cerebral oxygen utilization; repositioning; fever control; hypertonic saline; CPP augmentation; repositioning/kinetic therapy; NMB; craniectomy (Bader, 2006; Bader, Littlejohns, & March, 2003; Chen et al., 2008; Haddad & Arabi, 2012; Littlejohns et al., 2003; Pascual et al., 2011; Rockswold et al., 2009; Spiotta et al., 2010). ***Responsiveness of $PbtO_2$, ICP and MAP to physiologic interventions is found in figure 8.***

The patient reflected in the collected data had severe TBI consequent to a severe fall down 15 steps in his home. She underwent aggressive, mechanism-based therapy for deteriorating neurological examination including hemicraniectomy. Following $PbtO_2$-directed therapy she recovered to in-patient rehabilitation.

TBI Case Study-Conclusion and Recovery:

With ICP stable during monitoring in the postoperative period and remaining stable, and intracranial compliance improving and serial head CT's showing improving intracranial physiology multiple steps toward recovery and ventilator liberation became possible. One step was downward titration of neuromuscular blockade to off with recovery of neuromuscular function as determined by clinical examination (cough, gag reflexes) initially and train-of-four evoked responses of 4/4 at 50 Ma current output. A second step was downward titration and discontinuation of CNS depressants (fentanyl and midazolam). Clinical response was a marginal increase in responsiveness to stimulation with patient-triggered ventilations.

Follow up head CT revealed initial resolving brain edema, ventricular system remained compressed but not deviated away from midline, as well as additional detail in sulci. ***Head CT representative images and results summary are found in figure 9.***

The patient became increasingly responsive to family members. Ventilator weaning proceeded as clinically appropriate, ventilator liberation was achieved and she progressed dramatically with physical therapy in the critical care unit. This continued through bedside work with therapy professionals through increasing activity and ambulating with assistance around the unit. With high motivation as well as encouragement from her family and caregivers and significant hard work she was discharged to home after in-patient rehabilitation. Just 22 days after her traumatic brain injury, the patient was ambulating around the unit (with supervision), able to communicate and expressed thanks to the team of caregivers who “saved her life” and rescued her from a “close call with death.”

Nursing considerations:

Care of any patient following severe TBI remains among the most challenging in critical care practice. Severe brain trauma affects all body systems and can stimulate a hypermetabolic state, complicating nutritional support. Patient risk may be due to therapeutic interventions such as airway management and invasive lines/drains risking hospital-acquired infections such as VAP, bloodstream infections or meningitis. Aggressive measures to attenuate these risks include aggressive surveillance of signs of infection, meticulous care of any invasive lines such as central venous catheters and site rotation for peripheral IV catheters. Careful and frequent assessment of operative sites (craniotomy/craniectomy), ICP monitoring/wound and CSF drain sites is imperative. Assessment and documentation of CSF and other drainage for color, amount, character and condition of any drain sites are vital to early identification and intervention for complications.

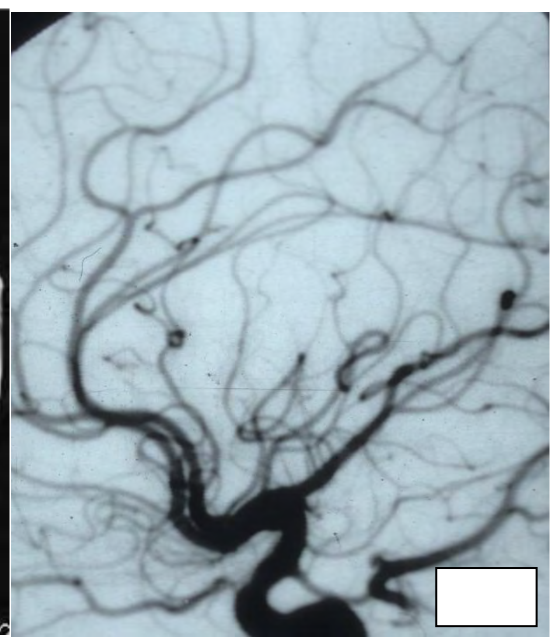
Surveillance of the clinical neurological examination, trends in ICP over time and in response to stimulation as well as detailed ICP waveform analysis if this technology is available and used. These assessments are paramount in determining progression of injury, response to therapeutic interventions, intracranial compliance and intracranial responses to stimulation and nursing care activities such as pulmonary care, repositioning and tactile as well as auditory stimulation in a critical care area. Aggressive pulmonary care including detailed lung assessment, maintaining patient-ventilator synchrony and monitoring oxygenation and ventilation are critical. Pulmonary physiology and intrathoracic pressure dynamics alter intracranial physiology and ICP due to risks associated with hypoxemia, hyper/hypo-capnia and surges in intrathoracic pressure being transmitted to the intracranial cavity through the jugular venous system. Careful determination of actual intake/output (including potential insensible fluid losses) and judicious fluid management can maintain adequate circulating blood volume and modulate risk of fluid/electrolyte imbalances. Aggressive feeding protocols are needed to match caloric intake with metabolic needs particularly following severe trauma and subsequent hypermetabolic state. Early nutrition support is recommended, is associated with improved survival and decreased degree of disability and enhances immune function (Helmy et al., 2007). Maintaining close control of blood glucose levels by titrating insulin therapy is also appropriate(Helmy et al., 2007). Hyperglycemia is associated with progression of secondary brain injury and worse outcomes (Brain Trauma Foundation et al., 2007h; Helmy et al., 2007). Deep vein thrombosis (DVT) prophylaxis appropriate. Non-pharmacological interventions such as sequential compression devices and pharmacological interventions such as unfractionated or low-molecular-weight heparin are options (Brain Trauma Foundation et al., 2007h; Helmy et al., 2007; Ling & Marshall, 2008). Seizure risk may be reduced post-TBI by administration of anticonvulsant agents such as levetiracetam, carbamazepine or valproic acid as clinically appropriate due to risk of secondary brain damage (Brain Trauma Foundation et al., 2007i; Ling & Marshall, 2008).

Nursing considerations and family needs.

Global nursing considerations include care directed at patients' families. The patient experience of severe TBI produces a cascade of effects within the family system. The family may experience almost unendurable stress, anticipatory grief and significant fear seeing someone they love so critically ill and vulnerable. Providing regular updates at an appropriate level of understanding establishes and maintains trust as well as lessens anxiety. Families consistently need information, professional support from the team and may benefit from some involvement in care and experience significant uncertainty during a family member's critical illness (Keenan & Joseph, 2010). Nursing implications for families include education, caring behaviors, involving families in care as appropriate, being aware of their own anxiety and how it may affect families as well as maintaining open communication and not avoiding families (Yetman, 2009).

Summary:

Worldwide, patients following severe TBI are among the most challenging and vulnerable populations in critical care practice. Primary brain injury typically begins the cycle of secondary brain injury which, if progressive and refractory to therapy, can prove fatal. Secondary brain injury may arise from evolving intracranial pathophysiology as well as other body systems including pulmonary, cardiovascular, neuroendocrine and GI dysfunction as well as hospital-acquired infections. For these reasons, optimal care of the patient following severe TBI must include aggressive, mechanism-based therapeutics for intracranial pathophysiology, focused surveillance of neurological assessment data and meticulous assessment and care for all body systems. Multidisciplinary collaboration and effective communication is key to rapid recognition of clinical changes quickly coupled with optimal clinical management in pursuit of neurologic recovery. Family needs are also key to long-term recovery and family communication, involvement in care as clinically appropriate and updates help significantly build trust which can only help with family interaction during critical illness.



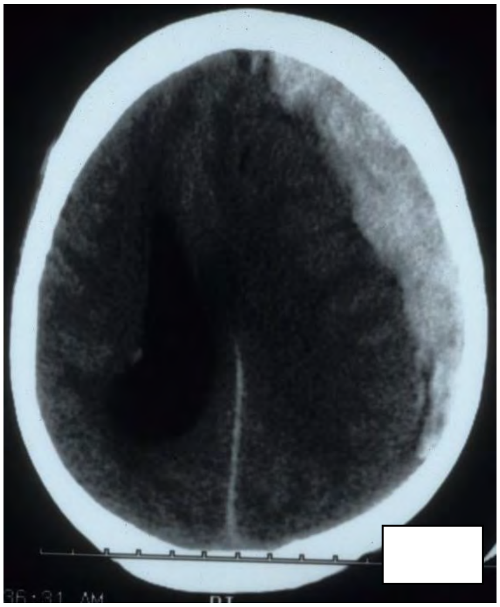


Figure 1: Illustration of ICP physiology. Figure 1-A illustrates normal CSF dynamics and brain bulk. Ventricular system normal and generally symmetrical and normal detail/no effacement of sulci/cerebral cortex. Figure 1-B illustrates normal cerebral arterial supply/distribution. In the smaller vessels, blood flow is at risk from compression due to edema and/or mass lesion. When ICP approaches/meets MAP, global brain blood flow is compromised, risking ischemic injury. These may be consequent to autoregulatory failure, hyperemia and/or compromised venous drainage. Cerebral blood flow extremes of hyperemic and oligemic flow states risk ICP increases and brain ischemia respectively. In figure 1-C (traumatic subdural hematoma), brain bulk (approx. 80 %) increases due to water influx. Cerebrospinal fluid (CSF) dynamics (approx. 10 %) may be altered due to obstructive or communicating hydrocephalus and ventricular system is significantly distorted. Brain blood volume (approx. 10 %) is affected due to compression/distortion of cerebral vessels. Initial ICP readings immediately following monitor insertion

Chapter 7

End Stage Liver Disease in the ICU: Walking a Tightrope

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Learning Objectives

After reviewing the chapter the learner will be able to:

1. Discuss the pathophysiology of liver failure.
2. Describe clinical manifestations of liver failure.
3. Describe nursing implications, diagnositics and treatment required in the patient experiencing liver failure.

Patients who suffer from end stage liver disease (ESLD) can present many challenges to the nurses caring for them. While they may appear to be stable, they are balancing on a very fine tightrope and life threatening complications can arise suddenly, requiring immediate attention to prevent catastrophic outcomes. The critical care nurse must be able to thoroughly assess for impending complications and always be prepared for a change in the patient's condition.

The liver plays many roles in maintaining health. It clears the body of ingested toxins, manufactures numerous clotting factors, helps to maintain vascular oncotic pressure by producing albumin and plays a role in glycemic control. As the liver fails, it can no longer carry out these normal functions leading to the complications that are associated with ESLD.

While the liver has a remarkable ability to recover and regenerate, when severe injury occurs, whether from disease, accumulation of toxins, such as alcohol, infection, such as chronic hepatitis, or other disorder, this regeneration can lead to fibrotic changes in the liver tissue. Once enough of the liver tissue becomes diseased and irreversible changes have occurred, a diagnosis of cirrhosis is made. These cirrhotic changes lead to an inability for normal blood flow through the liver as well as an inability for the liver to carry out its normal functions. The point is reached when there are not enough healthy hepatocytes remaining. The complications that are seen in ESLD are a direct result of these structural changes.

Hepatic Encephalopathy

Hepatic encephalopathy (HE) occurs in patients with ESLD as a result of a build-up of toxins able to cross the blood brain barrier and leads to changes in mental status. The exact cause of HE is unclear but there is strong association between elevation of circulating ammonia and severity of HE. Intestinal bacteria breakdown protein in the intestine leading to an increase in ammonia. When the cirrhotic liver is unable to metabolize the absorbed ammonia, it enters the systemic circulation and is able to cross the blood brain barrier, leading to changes in neurotransmitters and alteration in neurological function (1).

Hepatic encephalopathy is categorized by type and severity. There are 3 types of HE, type A which is associated with acute liver failure, type B associated with abnormal ammonia metabolism and no underlying liver disease, and type C associated with chronic liver failure (2).

Hepatic encephalopathy is further defined by grades (Table 1). Once a patient deteriorates to Grade 2, transfer to the ICU is warranted, as a continuous decline can lead to inability to protect the airway and respiratory failure. These patients require intubation and mechanical ventilation until their mental status improves.

Table 7-1: Grades of Hepatic Encephalopathy

Grades	Clinical Signs and Symptoms
1	Mild changes in personality, decreased attention span, loss of calculating functions. No asterixis present
2	Worsening personality changes, disoriented, incontinence, asterixis can be seen, reversed sleep/wake patterns
3	Somnolent but arousable from sleep, obvious asterixis, very confused with slurred, incoherent speech
4	Comatose and may or may not respond to noxious stimulation, may see posturing

Worsening HE can occur in patients who develop gastrointestinal (GI) bleeding or an infection. These patients must be closely monitored for decline in their mental status and the need for airway management (3). Lactulose can be used orally or via enema to trap ammonia and expel it from the GI tract. Doses should be titrated to 3 – 4 loose stools per day (2). Rifaximin, an antimicrobial, can be used to decrease GI bacteria which can decrease the amount of ammonia that is produced from digestion of protein. The usual dose is 550 mg two times per day (1).

Portal Hypertension

As cirrhotic changes in the liver worsen, blood can no longer flow freely through the liver lobules. There is an increase in venous pressure leading to increased pressures within the portal system. The development of portal hypertension contributes to a number of the complications we see in patients with ESLD including, ascites, gastroesophageal varices and variceal bleeding.

Ascites

Ascites occurs when protein rich fluid accumulates in the peritoneal cavity. The increased pressure in the portal system increases the hydrostatic pressure in the vessels causing fluid rich in protein to be forced out of the vascular space into the abdomen. This increases the oncotic, or water-pulling, pressure within the abdomen causing further fluid to pulled in (4).

Complications associated with ascites include infection, notably spontaneous bacterial peritonitis (SBP), and respiratory failure, occurring when enough fluid accumulates within the abdominal cavity to impede adequate respiratory function. SBP should be suspected in all ESLD patients who have any amount of ascites and develop a fever and abdominal pain (3). A diagnostic paracentesis can performed to look for white blood cells and bacteria in the ascites. If an infection is present, antimicrobials need to be started and the ascites may need to be completely drained from the peritoneal cavity.

Typically, ascites is controlled with diuretics. If enough fluid accumulates to compromise respiratory function, a therapeutic paracentesis may be performed to drain enough ascites to prevent the need for intubation and mechanical ventilation.

Gastroesophageal Varices

Although varices can occur anywhere within the splanchnic circulation, these collateral vessels are typically seen in the distal esophagus and the gastric fundus (5). An esophagogastroduodenoscopy (EGD) is used not only to diagnose varices, but to determine their severity and the likelihood of bleeding. Banding of problematic vessels can occur in order to prevent, or decrease the risk of a variceal hemorrhage (5). Beta blockers may also be used to decrease portal pressure and decrease the risk of bleeding, however patients must be closely monitored for systemic hypotension that may complicate this treatment option (5).

Variceal Hemorrhage

The rupture and bleeding from varices is the most life-threatening complication of ESLD. Immediate action is needed to protect the airway, maintain adequate perfusion and replacing both blood and clotting factors. Patients with bleeding varices require intubation and mechanical ventilation. Volume replacement can include crystalloid solutions as well as blood transfusions to attain a hemoglobin of 8g/dL. Fresh frozen plasma (FFP) is needed to replace clotting factors that are not adequately produced in the diseased liver with the goal of an INR < 1.5. Platelet transfusion may be necessary to increase the platelet count to > 50 x 10^9/L (5).

In order to control bleeding, an EGD may be performed to identify the vessel. If bleeding can't be controlled with banding during the EGD, balloon tamponade may be necessary. Pharmacological intervention is also necessary including splanchnic vasoconstriction with medications such as somatostatin or octreotide (5). Vasopressin, the most potent splanchnic vasoconstrictor, may be used, however there are numerous side effects associated with its use and patients need to be closely monitored for the development of both peripheral and cardiac ischemia (5). Patients who develop variceal hemorrhage are also at a higher risk of developing bacterial infections and should receive a course of prophylactic antimicrobials (5).

Coagulopathy

The liver is responsible for the production of many of the clotting factors necessary for normal coagulation. In addition, Vitamin K, a fat soluble vitamin, is needed to for the production of many components of coagulation. In ESLD, the liver may not be able to synthesize adequate clotting factors which is reflected in an elevation of the prothrombin time and INR. If there is not adequate bile production, Vitamin K may not be absorbed in sufficient amounts.

When there is active bleeding, or if there is a high risk of bleeding, FFP may be transfused to decrease the INR to < 1.5. Vitamin K may be given orally or intravenously in attempts to decrease the INR, however, if the liver is unable to produce clotting factors, no change in the INR may be seen (4).

Hepatopulmonary Syndrome

In patients with ESLD, changes in the pulmonary vasculature may be seen which can lead to hypoxemia. Hepatopulmonary syndrome (HPS) is not clearly understood and there are currently no ideal therapies, beyond liver transplantation, that can lead to improved oxygenation (6). Patients who suffer from HPS may qualify for liver transplantation even if their liver disease is not severe enough to warrant transplantation.

Additional respiratory complications can occur as a result of abdominal ascites. An hepatic hydrothorax occurs when ascitic fluid passes up from the peritoneal cavity and through the diaphragm (7). This is typically seen in the right pleural space and, depending upon the volume, can compromise ventilation.

Hepatorenal Syndrome

Hepatorenal syndrome may be seen in patients with ESLD. Decreased renal function can occur from actual damage to nephrons, can be a consequence of liver failure or can be a combination of the two. It can be difficult to differentiate between HPS and other causes of renal failure in patients with ESLD and the diagnosis of HRS is typically made when other causes of acute renal failure have been excluded (8). Patients who have HRS typically suffer from oliguria that is not responsive to either volume or diuretics (3). These patients frequently are hyponatremic and have a low urine sodium level, similar to that seen with pre-renal renal failure.

Although there are temporizing therapies that can be started, including intermittent hemodialysis or continuous renal replacement therapy, liver transplantation is the best option for patients who are eligible to be transplanted (8). Renal function may not immediately return to normal and patients and families have to be made aware that renal replacement therapy may be needed for a period of time after receiving a liver transplant.

Support

Without a liver transplant, patients with ESLD will not survive and this can be devastating to both the patient and the family. There is a tremendous amount of psychosocial support that is needed. Not all patients are good candidates, or are eligible to receive a transplant. Any complication can be the one that leads to their death. Even those who are on the waiting list for a new liver may develop complications that will remove them from the waiting list. This then requires patient and family discussions related to the level of aggressive, life sustaining therapies and end-of-life care.

It is a difficult balancing act to maintain normal functioning for as long as possible. One small change, such as an infection, can lead a patient to lose their balance on that tightrope and end up critically ill in your ICU.

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Chapter 8

Pediatric Critical Care Concerns

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Learning Objectives

1. Discuss evolving information concerning the developmental impact of a pediatric intensive care unit (PICU) admission.
2. Understand the foundations of patient- and family-centered care and their relevance to promoting compassionate nursing care and the safety of children in the PICU
3. Understand the context of medication errors in the PICU and describe strategies to mitigate medication errors
4. Identify key priorities for nursing research as identified by an international cadre of pediatric critical care nurse scientists
5. Identify resources PICU nurses can use to increase their knowledge base and educate other nurses in the care of critically ill children

Introduction

Pediatric critical care is delivered to hundreds of thousands of children every year. Pediatric intensive care units (PICUs) are located on every continent, although not in every country. Developing countries face particular challenges in terms of adequate and appropriate staff, access to specialty care, and the availability of technology and other resources.[1] Nurses are an integral and key part of the health care team in any PICU. PICU nurses must develop a strong knowledge base in the care of critically ill children in general and a particular and in-depth knowledge of the disease processes and syndromes most commonly seen in their PICU, in their part of the world.

Fortunately, PICU nurses are skilled at establishing relationships and building bridges. They do this by sharing knowledge with their colleagues, and through programs such as the Sister PICU program developed at Boston Children's Hospital (information accessed at http://www.wfpiccs.org/projects/wfpiccs-sister-picu-program/). In keeping with that goal, this chapter aims to discuss key pediatric critical care nursing concerns and provide the reader with useful resources, regardless of where they are located in the world.

Defining Pediatric Critical Illness Across the Globe

Critical illness is a broad term that encompasses life-threatening illness requiring close and near constant attention from health care providers in a highly controlled setting.[2] In developed countries, this complex and advanced level of care typically occurs in a hospital's intensive care unit (ICU), specifically the Pediatric ICU (PICU) for the pediatric population. Critical illness usually requires the use of sophisticated monitoring devices, such as central venous and intracranial pressure catheters, as well as modes of organ support, such as hemodialysis, mechanical ventilation, and vasopressors.[3]

Historians identify critical care medicine as beginning in the 1950's, when providers employed invasive mechanical ventilation for Danish patients suffering from poliomyelitis. Students manually ventilated these patients, and the patients also received "intensified nursing support."[3] These actions resulted in decreased mortality rates, which then encouraged the establishment of the specialized units delivering a high level of surveillance that we know as ICUs.[3,4]

Just as “a child is not a small adult,” the PICU is not identical to an adult ICU. While both necessitate diligent monitoring and observation, pediatric patients present challenges in their ability to compensate before abruptly deteriorating; their weight-based dosage requirements and variable metabolism; and, depending on age, developmental obstacles that prevent a concise articulation of symptoms and expression of comfort level.

However, in a developing country that may lack sophisticated equipment and highly trained specialists, critical illness becomes even more time-sensitive and difficult to treat. Sepsis, severe injuries, and respiratory failure are among the most common reasons for PICU admissions in the United States (US). Sepsis is also a frequent reason for PICU admissions internationally. In fact, worldwide, severe sepsis is the leading cause of death in children, usually as a result of multiple organ dysfunction syndrome (MODS) that leads to multiple organ failure (MOF). (NIH, CPCCRN, n.d.). Even in developed countries with plentiful resources, hospital mortality rates for pediatric cases of severe sepsis range from 30% to 60%.[5]

In order to better characterize this, Weiss et al[6] undertook a prospective cross-sectional study investigating sepsis prevalence in 128 PICUs in 26 countries with data collected at five time points in 2013 to 2104. This point prevalence study demonstrated that the prevalence of severe sepsis in children admitted to PICUs was variable by global region. In North America, Europe, Australia, and New Zealand 6 to 8 percent of patients diagnosed with sepsis were treated in PICUs, with PICU mortality ranging from 21 to 32 %. Ten PICUs across Asia and 10 PICUs across South America reported that 6 to 8 % of patients were treated in PICUs with mortality rates of 40 % in Asia and 11 % in South America. The three South African PICUs participating in the study reported an admission rate of 25% of patients with severe sepsis with a mortality rate of 40 %. In the US pediatric severe sepsis accounts for 4.4 % of admissions to children's hospitals and 7 % of patients treated in PICUs. In China, the incidence of sepsis in China is estimated at more than 360,000 cases annually.

Related to sepsis but also considered separately, instances of particular single organ dysfunctions also lead to critical illness: illness and injury affecting cardiovascular and neurologic systems have higher mortality rates than those affecting the hepatic and renal systems.[7] Point prevalence studies conducted since 2007 in 59-120 PICUs found in 7-28 countries showed a prevalence of 10.8% for acute lung injury requiring mechanical ventilation and an 18.7% prevalence of acute critical neurologic disease, the latter of which had a 12.4% mortality rate.[6] Acute critical neurologic conditions include cardiac arrest, stroke, traumatic brain injury, brain mass, status epilepticus, spinal cord disease, and hydrocephalus. The prevalence of severe sepsis/septic shock in these studies was unavailable, potentially due to lack of consensus among sites and/or countries regarding what criteria must be fulfilled for these complicated and rapidly evolving diagnoses.

Respiratory and bloodstream infections are found in almost two-thirds of cases of severe sepsis worldwide. However, in a country like South Africa, patients concurrently battling HIV/AIDS and tuberculosis may require the resources of pediatric critical care medicine. Because critical illness syndromes such as sepsis cannot be diagnosed the same way HIV can, data for its prevalence is not always readily available. This, in part, was the impetus for the previously referenced study by Weiss et al.[6] Relatedly, definitions for sepsis or acute lung injury are debatable and continuously revised, which further makes defining critical illness across the globe in general particularly arduous. In countries with few, if any, ICUs or ICU-level supplies and providers, critical illness only briefly exists as “critical illness” because unfortunately, it quickly progresses to death. It is for this reason, joined with the intention of studying comparative epidemiology, that critical illness is sometimes relegated to illness that is treated *within* the ICU.[3]

Developmental Impact of Pediatric Critical Illness

A PICU admission is a stressful experience for the child and for the family. Most pediatric critical care research is focused on the time period of the admission itself. But the majority of children are discharged from the PICU, and research on long term outcomes is very limited. However, in the last five years there has a significant increase in studies assessing long term sequelae, and it appears that there may be some long term effects of a pediatric critical illness. Most of the research in this area has been done at a single site or a small number of sites, so it is difficult to generalize the results, but there is sufficient evidence to warrant further studies in larger populations.

Early data suggests that there may be negative effects on neurocognitive development. Two small studies of children admitted to the PICU for septic shock found a significant proportion of the children had decreased cognitive functioning.[9,10] Bronner et al found the effect more pronounced in children admitted at a younger age.[9] The aspects of cognitive functioning impacted in these two studies were memory, IQ, and executive functioning which involves reasoning and problem solving. In some children attention was also impacted. [9,10] van Zellem and colleagues[11] studied children admitted to the PICU with meningococcal septic shock at 4 years after PICU discharge and found similar impairments of neurocognitive functioning. In an effort to tease out associated factors, they examined the use and dose of opioids, benzodiazepines and pentobarbital. Opioids and pentobarbital were both associated with poor test performance on IQ, specifically verbal scores and vocabulary, as well as attention and executive functioning. Other small studies have identified issues with strength and motor function as well as cognitive deficits.[12]

It is important to remember that these are small studies suggesting a possible trend, but larger studies in more diverse populations are needed to see if there is a real association. However, it does provide support for the use of nurse managed sedation protocols which allow the downward titration of sedation infusions as well as increase, to ensure the child remains on the lowest possible dose needed to achieve a sedation target goal.

Immediate Stabilization of the Distressed Pediatric Patient

As previously discussed, sepsis is a leading cause of death in critically ill pediatric patients and one of the primary reasons children are admitted to PICUs throughout the world.[6,13] A second common cause of PICU admissions and pediatric morbidity and mortality is traumatic injury, including burns. Recommendations for the initial management of these patients are found in guidelines developed by international groups of experts. The primary guidelines discussed here will be the Pediatric Advanced Life Support (PALS) guidelines,[14,15] developed by the American Heart Association (AHA) in collaboration with the International Liaison Committee on Resuscitation (ILCOR) as represented by an international group of pediatric resuscitation experts, and the Clinical Practice Parameters for Hemodynamic Support of Pediatric and Neonatal Septic Shock: 2007 update from the American College of Critical Care Medicine (ACCM).[16] The Surviving Sepsis 2013 Pediatric Guidelines also summarize the ACCM data.[17]

The Surviving Sepsis Campaign[18] was developed in early 2000 in response to recognition that sepsis was a significant and growing problem worldwide and affected patients of all ages.[19] The explicit goal of the campaign, published in 2002, was to reduce mortality from sepsis by 25% in 5 years. The initiative is led by the Society of Critical Care Medicine (US) and the European Society of Intensive Care Medicine with leadership also provided by the International Sepsis Forum. The initial guidelines have been updated several times, most recently in 2015, and the website provides pediatric-specific guidelines and several tools for education and quality improvement. There are several reports in the literature of how ICUs in less well-resourced countries, including PICUs, have successfully implemented the ACCM/Surviving Sepsis guidelines.[20]

Early recognition of shock in children is linked with improved outcomes.[14,21-24] Close, careful and ongoing assessment is the cornerstone of managing children in shock, regardless of the etiology. If the initial interaction with the child is at the time of presentation, use of the Pediatric Assessment Triangle, part of the AHA pediatric emergency management programs including PALS, is a very useful and rapid tool.[25] It involves rapid assessment of three parameters. The first is general observation: does the child look sick or not sick? This is based on a rapid observation of the child's tone, interactiveness, ability to focus and/or track, and the presence or absence of verbal communication. In the infant, strength of cry is observed. The second is quick assessment of respiratory status looking at abnormal position to facilitate breathing, abnormal airway sounds (stridor, wheezing, muffled voice, grunting) and work of breathing. The presence of retractions, nasal flaring and abnormal breathing all contribute to the "sick" categorization. Finally, a quick visual assessment of skin perfusion, specifically the presence of pallor, mottling or cyanosis result in a “sick” determination. If any of the categories meet the criteria for “sick” categorization, emergency management should be rapidly instituted. This is particularly useful for Emergency Department nurses who are responsible for triage of incoming patients, but is also useful in mass-casualty situations for rapid sorting.

Assessing for the presence and degree of shock is key, as it directs appropriate treatment. The ACCM pediatric guidelines include the following criteria for the identification of septic shock: fever, tachycardia and vasodilation plus a change in mental status and/or other signs of inadequate tissue perfusion. Guidelines are provided for age specific heart rate (HR) thresholds. The threshold for newborns through one year is 120-180 beats per minute (bpm); over 1 year to 2 years 120-160 bpm, over 2 years to 7 years 100-140 bpm; and over 7 years to 15 years 90-140 bpm. In addition to HR, peripheral perfusion as identified by mental status, capillary refill time (CRT), presence and quality of peripheral pulses and extremity temperature is used to follow treatment effectiveness.[16]

The ACCM sepsis guidelines stress that the goal should be rapid initiation of treatment and a goal has been set that reaching the threshold heart rate for age, normalizing blood pressure and achieving a CRT of ≤ 2 seconds should occur in the first hour. It is also key to begin antibiotics within the first hour.[16]

As soon as assessment identifies the presence of likely septic shock, high flow oxygen should be initiated and vascular access should be obtained. If intravenous (IV) access cannot be achieved quickly, an intraosseous needle should be placed. Rapid boluses of 20 mL/kg of isotonic saline should be given unless the child presents with rales or hepatomegaly. The guidelines indicate that total volumes of up to or more than 60 mL/kg may be required. In the child requiring large amounts of volume, inserting a second IV or a central venous catheter should be considered.[14,16]

Fluid boluses followed by reassessment should continue until heart rate, blood pressure and perfusion have normalized, and urine output is ≥ 1 ml/kg/hour, or rales or hepatomegaly develop. If volume resuscitation is not effective, or hepatomegaly or rales develop an inotrope should be initiated, typically dopamine or epinephrine. Although inotrope administration via a central route is preferred the guidelines indicate that low dose dopamine or epinephrine may be given via a second peripheral IV line. Use of a carrier fluid to dilute rapidly deliver the drug, along with close observation of the IV site are critical. In the child with continued refractory shock who is at risk for absolute adrenal insufficiency, hydrocortisone may be given. [14,16]

During the initial treatment phase, respiratory status should be closely monitored. Increased work of breathing, hypoventilation and markedly impaired mental status are all indications for intubation. Placement of central vascular access may also require intubation. It is important that volume resuscitation be initiated before intubation or sedative administration in order to avoid hypotension.[16]

The final recommended therapy, if available, is the use of extracorporeal membrane oxygenation for children with continued refractory shock and respiratory failure. During this initial fluid resuscitation it is also important to assess for and correct hypoglycemia and hypocalcemia, but it is also key to avoid hyperglycemia, using a target for serum glucose of ≤ 180 mg/dl (10 mmol/l).[16] The most recent guidelines are available at: http://www.survivingsepsis.org/Guidelines

Shock is also frequently a presenting symptom in children with traumatic injuries, and a systematic process of assessment and management is also key in the child with trauma. The elements of the pediatric trauma algorithm are completion of a primary survey, during which life threating injuries are identified and treatment is rapidly instituted; a secondary survey, in which all injuries are identified and treatment is instituted as appropriate, and finally determination of ongoing care needed. The primary survey is organized around the pneumonic ABCDE, although in reality Airway, Breathing, and Circulation are typically assessed and managed simultaneously. Impaired circulation is identified using the same assessment parameters described for the child with septic shock: heart rate, blood pressure, peripheral perfusion, urine output. In the case of traumatic injury, hemorrhage is also likely, and sources of bleeding are assessed for as part of the Circulation survey. C also represents cervical spine assessment, which is important in the child, as cervical spine injuries are more common in children than adults, particularly after motor vehicle collisions or falls.[14, 26]

D represents disability, or neurological status. Children are at high risk for head trauma and ongoing monitoring of neurological status using the Glasgow Coma Scale or in the emergency setting, the AVPU (alert, verbal, responds to pain only, unresponsive) scale is critical. Assessment for neurovascular injury is also important. E represents both exposure, to identify sources of significant bleeding and injuries not readily apparent as well as environment. Small children particularly are at risk for hypothermia and the environment should be managed to prevent ongoing heat loss.[14,26]

Key elements in the care of the pediatric trauma patient include identifying and rapidly managing life-threatening injuries, including shock and respiratory failure; avoiding hypothermia and in the child with a head injury avoiding hyperthermia. Volume resuscitation and control of bleeding are important aspects of treating shock. Additionally, hyperglycemia should be avoided in the pediatric trauma patient, particularly the child with head trauma, as hyperglycemia has been associated with worse neurological outcomes in this population.[14, 26,27]

Children with burn injuries are a special subpopulation of pediatric trauma patients. This population is also at risk for shock due to increased fluid loss through the burned areas. For this reason appropriate calculation of the extent of the burn, using a tool such as the Lund-Browder chart, is done in order to calculate fluid resuscitation requirements. Rapid and complete fluid resuscitation and careful attention to ongoing assessment of circulatory status is key. Children with burn injuries may be at increased risk for respiratory failure due to airway edema after thermal injury or circumferential chest burns which constrict chest expansion. If respiratory assessment reveals drooling, oropharyngeal edema, the presence of soot, or poor chest expansion further respiratory support will be required. Additionally, due to disruption of the skin, children with burns are at increased risk of hypothermia.[14,28]

Care of the distressed pediatric patient, regardless of the underlying cause relies on a few key factors. Skilled initial assessment, rapid and appropriate management, and ongoing assessment of response to therapy are key. Specialty organizations such as SCCM, the European Society of Pediatric and Neonatal Critical Care, the American Academy of Pediatrics, the Pediatric Trauma Society, and the American Burn Association and the International Society for Burn Injuries provide guidelines to assist in ensuring appropriate care for pediatric patients.

Child- and Family-Centered Care and its Impact on Patient Safety

The patient-centered care philosophy began in 1969 with the goal of assessing the patient's vision about on the quality of care received in the hospital. This has evolved over the years to a broader concept encompassing the family, and in 1990, the term "Patient-and family-centered care" (PFCC) emerged. In order to support family-centered care, the Institute for Family-Centered Care was created, promoting the following principles: respect and dignity for the patient and family; shared information between the patient, family and healthcare team; and patient (when possible or appropriate) and family participation in decision-making and collaboration.[29]

PFCC explicitly identifies the importance of involving the family and patient as essential members of the healthcare team. In the majority of situations where a child has a serious health condition, this involvement has positive therapeutic effects on recovery and benefits for the family and staff.[30,31] However, this practice is still in the process of being incorporated into practice by many PICUs across the globe.[32,33] In general, healthcare organizations strive to follow the principles of PFCC. The Institute of Medicine, Institute for Healthcare Improvement, and the American Academy of Pediatrics work in conjunction with the leadership of hospitals and other healthcare organizations to facilitate the involvement of the patient and the family as involved members of the team, in order to advance the practice of PFCC.[29, 34-36]

It is known that nursing professionals often spend the most time with the patient and family during a hospital admission, and thus can ensure PFCC is at the center of nursing practice. The incorporation of PFCC into the nurse's practice facilitates holistic and safe care. In 2003 the Society of Pediatric Nurses and the American Nurses Association published *Family-Centered Care: Putting It into Action: The SPN/ANA Guide to Family-Centered Care*. The handbook provides practice recommendations to assist with incorporating PFCC into the care of all pediatric patients across all settings. The recommendations are based on a framework that recognizes the mutual beneficial partnership that should exists between patients, families and healthcare professionals and are organized around the eight elements of family-centered care.[34,37]

This practice is important, as the goal is to promote the health and well-being of children and families in difficult times, such as during an intensive care admission. In addition, when implemented effectively, PFCC will improve recovery and patient and family satisfaction.[38]

The PFCC approach is focused on respect for cultural values, acknowledging the previous experiences of each individual, emphasizing attitudes of partnerships, encouraging shared decision-making, and recognition of the roles and strengths of each family member. When consistently implemented, PFCC can facilitate increasing competence of children and young adults in taking responsibility for their own health.[38]

Patient Safety Promotion in the PICU: Strategies Used

Beginning in 2007, the National Patient Safety Foundation and The Joint Commission began encouraging healthcare organizations to adopt guidelines promoting interdisciplinary work and collaboration in order to improve patient safety and care quality. A significant component of this strategy promoted the development of a culture of safety within the hospital, especially within the PICU.[39-41]

Additionally, a campaign developed by the World Health Organization called "Patients for Patient Safety" detailed the importance of each patient's participation in promoting their own safety. Key to this campaign is the assumption that when the patient participates in the process of care through collaborative practice and patient-centered care, they become able to promote their own safety.[42,43] However, many factors hinder such participation, especially in health systems in which patient autonomy is culturally opposed, due to a paternalistic attitude and resistance of the healthcare professional to shared decision making. An additional challenge related to pediatric patients may be promoting respect for the child's autonomy and involving the child in care and decision-making as appropriate.[44,45]

This difficulty can be understood, because care must be individualized based on the patient and family's specific needs. Some strategies proposed by PFCC proponents in order to overcome this situation are related to the involvement of the patient and family, emphasizing that they should be encouraged to participate as allies in patient safety, which will reduce the stress and anxiety of children and improving the family's satisfaction with care. [34,35,46] Studies suggest additional ways to promote child and family-centered care such as:

- Promote information sharing and effective communication between families and professionals. [47-51]
- Include patients and families in interdisciplinary discussions at the bedside, such as patient care rounds. [47-51]
- Use tools or checklists that promoting safer care which also foster parental involvement in the care of their child.[47,52]
- Provide family assistance to ensure the family's physical needs such as accommodation, food and hospital expenses are met. This can reduce the stress of parents while their child remains in the PICU.[53]
- Provide family assistance to ensure the biological, psychological, social and spiritual needs of the child and family are met.[54]
- Create a Commission or Advisory Committee related to PFCC and appoint family members as leaders who are able to participate effectively in the work of the Commission or Committee. These individuals may also serve on subcommittees and working groups dealing with operational issues such as how to involve families in planning their child's health care and assistance in ways to provide support to other patient and family programs.[34,35,46,55]

- Provide education and support for patients, family and family-centered care team and share complete and accurate information in order to participate in care and decision making. [29,55]
- Follow up with children and their families after PICU discharge in order to identify unmet needs and evaluate care in order to propose effective improvements.

Efforts to implement PFCC in the PICU can also include open visitation, family presence during invasive procedures, and family conferences.[30]

Many professionals are knowledgeable about PFCC, however, the stress of the PICU environment and care specific to seriously ill children can cause PFCC to become less of a priority. When this occurs, the benefit of PFCC is not realized and patient outcomes and parent satisfaction are negatively impacted.[48] In this situation it is important that the health institution seek ways to assist the team in providing holistic care focused on the patient and family, minimizing errors of omission in PFCC and promoting the child's safety.

Patient Safety Issues in the PICU

Considering all sources of error that may occur during a healthcare encounter, medication errors (ME) are the most common and also the most frequent cause of adverse events (AE) and harm.[56,57] This is concerning because in the pediatric patient medications are usually dosed based on weight; this increases the opportunity for harm.

In the past, medication errors in children were reported in case series or individual reports. The possibility of systematic evaluation of error rates in this population occurred only recently,[58] however the incidence of harm due to ME and AE is well documented among hospitalized patients in general. Research has shown that the potential risk for ME within the pediatric inpatient population is about three times more frequent than with adults, and when ME do occur they have a much higher risk of death than do adults. This is in part due to the narrow margin of error for fluid or medication dosing.[59]

Evidence suggests that for each ME that harms an adult patient, there are 100 undetected errors. Approximately one in every 100 ME results in what is known as an adverse drug event, in which a patient is harmed or dies as a result of drug administration or omission. Keeping in mind how many inpatient medication orders are written each day, the number of pediatric ME in the PICU is likely to be surprising.[60] In the PICU the staff provides complex care that is high risk, and involves the administration of multiple medication doses. This presents numerous opportunities for failure or near misses related to fluids and medications.[61]

Studies have also shown which children are most vulnerable to ME. At risk groups include children younger than two years and children admitted to the PICU or neonatal ICU (NICU). NICU patients are particularly at risk due to their small size. Children seen in the Emergency Department, especially if they are seriously ill or seen in the hours from 4:00 am to 8:00 am or on weekends, children receiving chemotherapy, or miscellaneous IV medications and those whose weight has not been documented are also particularly vulnerable.[60]

According to the results of a literature review, the average ME rate identified was 105.9 ME per 1000 patient-days in adult ICU patients and 24.1 ME per 1000 patient-days in the NICU and PICU.[62] This difference may be attributed to the detection method used to identify the ME and also variability in how ME were defined and classified in the different studies.[63]

In 2009 the World Health Organization (WHO) published the Conceptual Framework for the International Classification for Patient Safety. The goal of this document was to encourage standardization and to provide a mechanism to provide a method to organize and compare patient safety data and information between disciplines, institutions and across borders all over the world, in order to identify potential safety issues and provide opportunities to learn from ME.[64]

Another initiative addressing ME reporting is the National Coordinating Council for Medication Error Reporting and Prevention (NCC MERP). This United States based council, created in 1995, is made up of both consumer and medical organizations. NCC MERP adopted a Medication Error Index and algorithm which is used to classify an error according to the severity of the outcome, promoting standardization in reporting of ME. The index considers factors such as whether the error reached the patient, if the patient was harmed, and to what degree. It is hoped that standardization will help health care practitioners and institutions measure and publish their practice and be able to compare their indicators to other organizations.[65]

Classifying ME in a standard fashion may address the challenge of detecting the cause of the failure or ME that occurred in the health care setting. Identifying the underlying cause of ME remains a relevant opportunity for improving care in the PICU and the current mechanisms involve passive notification of ME. Voluntary incident reporting is the most common source of ME tracking. However, in general, incident reports have a number of inadequacies including underreporting, a dependence on a positive cultural norm that encourages reporting and the potential that the reports are not sensitive and representative.[61]

Buckley and colleagues[66] demonstrated their findings using direct observation of the medication administration process to identify ME in a PICU. They affirm that this method is more assertive than the passive notification. This function can be performed by a clinical pharmacist, encompassing the observation of the practice (procedure), analyses of the prescribing orders and also the audit of the patient medical record.

Another active search resource called the Trigger Tool was developed by the Institute for Healthcare Improvement (IHI) and Premier (a health care alliance comprising 1600 hospitals across the US). This tool is used in retrospective chart review to detect possible adverse drug events (ADE). The modified technique has been tested in 86 hospitals and consists of a checklist of high-alert drugs, antidotes, blood test values, transfer abruptly to high level care and or abrupt stop orders which serve as sentinels that something could be wrong and causing harm to any patient. A list of triggers and processes identified is available in the IHI website and can be used to systematically track ME in the PICU with a consist sensitivity.[67]

Sharek et al aimed in their study to actively track both potential ME (near misses) and ME resulting in real harm in the NICU. Their results showed that only 8% of ME were identified using traditional voluntary reporting methods, but trigger tools appeared efficient and effective at identifying AE.[68]

The investment of significant effort to measure AE must result in ''learning'' on the part of the organization. This is done by analyzing what has occurred, identifying the root causes and developing an effective action plan to mitigate the source of error. Some authors have suggested use of Six Sigma methodology to decrease MEs by analyzing medication administration processes. The framework is described by the pneumonic DMAIC, which stands for Define, Measure, Analyze, Improve and Control to systematize effective processes.[69]

It is important to recognize that erring is a human characteristic, and a multi-step process provides several points where an ME may occur in the PICU. Errors may occur at any point from the time the drug is sourced from the pharmacy until monitoring of clinical effects after medication administration has occurred. In addition to the resources previously discussed, the American Academy of Pediatrics (AAP) has issued a policy statement on "Principles of Pediatric Patient Safety" that must be considered when evaluating safety practices in the PICU.[70]

Developing a culture of safety is fundamental in this process, which encompasses using a systemic approach instead of blaming individual people. A key element of a culture of safety is a non-punitive environment. In general, ME are not the result of an individual action but the product of a chain of events triggered by a poorly designed system.[62]

High-reliability organizations recognize variability as a constant and are focused on minimizing that variability and its effects. As in aviation, the goal is to be constantly attentive and committed to avoiding failures such as giving a wrong dose of medicine. Behaviors such as creating a complete picture of the steps involved in a process, demonstrating a commitment to resilience; deferring to team members with expertise; and having awareness of systems-based practices.

According to the AAP,[70] the optimal culture of safety requires an organization that supports four key elements: reporting, being just, being flexible, and learning. A reporting culture collects, analyzes, and disseminates data about medical errors and AE. A just culture focuses on a systems approach to human fallibility while holding accountable those who intend to harm or intentionally fail to adhere to policies and procedures designed to keep patients safe. A flexible culture is capable of adapting effectively to changing demands. Finally, a learning culture has the competence and the will to make the right conclusions on the basis of safety information and to implement changes when needed. A culture of safety promotes compassionate disclosure of its mistakes to those who have suffered harm from those mistakes.[70]

In the last ten years, some strategies to prevent AE and specifically ME in the PICU have been reported in many research reports. Specific actions are being implemented in PICUs and have demonstrated satisfactory results, including:

- Implement a mechanism for accurate patient identification
- Use checklists and fast hugs in multidisciplinary rounds
- Involve patients and families in care, by including in them in clinical decision making and in multidisciplinary rounds, taking into consideration their culture and language preference
- Implement an electronic medical records (EMR) including
    - computerized provider order entry (CPOE)
    - a clinical decision support functionality customized for pediatric and neonatal patients
    - an electronic medication administration record encompassing double-checks at the bedside, or forcing functions such as mandated bar-code scanning before the drug administration, with specific alerts for allergies and weight,
    - clinical documentation within the EMR
    - a data repository
    - results reporting

    - other component systems such as pharmacy (pharmacy attention and medication reconciliation) and laboratory[16-17]
- Implement automatic pharmacy systems with automatic devices for the distribution of medicines, preferably in unitary doses
- Implementation of an effective and a collaborative multidisciplinary partnership focused on pediatric patient safety
- The use of Multidisciplinary Clinical Protocols with an available pediatric specialized team to develop and implement the protocols
- Constant training of the multidisciplinary team about technical issues such as equipment, smart pumps, protocols and behavioral issues like disclosures using realist simulations, for example
- Effective participation of the leader in initiatives for patient-safety projects such as creating a tracking system, using knowledge of organizational goals and external agency mandates to target changes with wider impact
    - Standardization on selection of equipment, acquisition of technologic materials, risk scales, and pain scales
    - Decrease or to extinguish the use of verbal prescribed orders (only used in emergency situations)
    - Implementation of statements and policies guiding medication administration by mothers and relatives in the PICU
    - Implementation of assertive and safety communication tools such as SBAR[17] (Situation- Background-Assessment-Recommendation); a tool to frame handoff conversations to ensure that staff are sharing concise and focused information

Efforts to improve patient safety are a priority in most settings, however there is still much to be done. MEs continue to occur every day in every health care environment. Proactive leadership in the context of the PICU is a crucial and fundamental premise needed to facilitate the improvement of the quality of care and pediatric patient safety. There are many implications for practice and research in this field which can bring improved care to better assist our patients and principally do no harm.

Priorities for Research/Future Directions

Pediatric critical care as a specialty is still fairly young. The first PICU was opened in Sweden in 1955. Ten years later, the second was opened in the United States.[4] A critical mass of research addressing care of the PICU population developed in the 1980's, and nursing research specific to the care of critically ill children has increased in the last two decades, but many questions are yet to be answered.

This issue was most recently addressed by Tume and colleagues in 2014 at the Seventh World Congress on Pediatric Intensive and Critical Care. A one day open consensus conference was used to identify and prioritize research questions important to the practice of pediatric critical care nursing. Each member of a panel of nine international nurse researchers developed three research questions aimed at addressing gaps in knowledge in various pediatric critical care nursing practice domains. A total of 27 questions were presented to the 33 attendees of the conference. The attendees represented ten countries: Australia, Brazil, Canada, Denmark, The Netherlands, South Africa, Switzerland, Turkey, the United Kingdom, and the United States.[74]

After three rounds of group voting, four research questions were identified as the most important. The first was "identifying nursing interventions that directly impact the child and family's experience during the withdrawal of life support." Second was "evaluating the long-term psychosocial impact of a child's critical illness on family outcomes." Third in priority was "articulating core nursing competencies that prevent unstable situations from deteriorating into crises", and the final priority identified was "describing the level of nursing education and experience in pediatric critical care that has a protective effect on the mortality and morbidity of critically ill children."[74]

Two other recent surveys have also addressed this question using the Delphi survey technique. In 2012 Tume et al used an electronic Delphi study to establish pediatric intensive care nursing research priorities in twenty European countries.[75] Seven statements, related to end-of-life care, decision making around forgoing and sustaining treatment, prevention of pain, education and competencies for pediatric intensive care nurses, reducing healthcare-associated infections, identifying appropriate nurse staffing levels, and implementing evidence into nursing practice were ranked highest. In 2007 to 2008, Ramelet et al conducted a Delphi study to identify National PICU nursing research priorities in Australia and New Zealand. After three survey rounds, priorities identified were: patient issues related to neurological care; pain, sedation, and comfort; best practice at the end of life; and ventilation strategies. In addition, two nurse-focused priorities were also identified.[76] Both of these studies tended to focus more on clinical skills rather than a larger vision for future the future of PICU nursing, but as in the international survey, these groups also identified pain management, sedation, and comfort measures as important research topics.

Although the results of these three studies are not completely in alignment, pain and sedation, end-of-life care, and PICU nursing competencies are themes that emerge as important for each of these groups. This suggests that these are areas ripe for further nursing research.

In addition to nursing specific research, PICU nurses have the opportunity to collaborate with other disciplines in developing new knowledge and improving the care of PICU patients. In developed countries in particular, where PICU survival rates are increasing, new physical, cognitive, and psychological challenges can emerge after discharge. Post-Intensive Care Syndrome (PICS) is a relatively new term describing these challenges, which can range from muscle weakness to depression. While studies are still few in number for the incidence of PICS, some research estimates that a third to a half of ICU patients experience PICS.[77-80] Data is sparse in general and specifically for the PICU population and PICU. A potentially important direction for pediatric critical illness research would be to examine patients with and without PICS at specific times along the post-discharge trajectory. What are risk factors and possible intervention or *pre*-vention strategies for a pediatric population so diverse, variable, and developmentally fluctuating? Just as pediatric critical care must address not only the emotional needs of the patient, but those of his or her family, this research should also include the effect of PICS on the family of the pediatric patient.

While the PICU must be a sterile, controlled, and often austere environment, it is also a home, however temporary, for a child who is sensitive to the surrounding sights and sounds. Future research should focus on how to create and support a comfortable and healing milieu, and how such a milieu affects patient outcomes and patient satisfaction. Additional research priorities could also include identifying more satisfactory modes of pain management while minimalizing adverse effects and excessive sedation, the effectiveness of telemedicine, especially in underserved areas, and how best to allocate limited resources for critical care in developing countries.

Infants, children and adolescents continue to require critical care in ever increasing numbers around the globe. Significant work is ongoing internationally with the goal of improving outcomes for critically ill children, particularly in the areas of sepsis and trauma. Several consistent research priorities have been identified as important for nursing, and nurse scientists have a real opportunity to continue their important work, as well as to collaborate with their colleagues in both nursing and other disciplines internationally. Taking advantage of these opportunities for collaboration will be key in minimizing the negative consequences of critically illness for children and their families around the globe.

Supplemental Tables

Table 8-1: Educational and program resources for pediatric critical care nurses

Course	Target Audience	Web Information	Notes
American Heart Association Courses International Services: http://www.international.heart.org/en/contact-us			
Basic Life Support	All members of the healthcare team caring for children	https://acls.com/pals-certification	Available as an online course
Pediatric Advanced Life Support (PALS)®	Emergency and ICU staff	http://cpr.heart.org/AHAECC/CPRAndECC/Training/HealthcareProfessional/Pediatric/UCM_476258_PALS.jsp	Supported by the American Association of Pediatrics
Pediatric Advanced Emergency Assessment, Recognition and Stabilization (PEARS)®	Pre-hospital and general care nurses	http://cpr.heart.org/AHAECC/CPRAndECC/Training/HealthcareProfessional/Pediatric/UCM_476633_PEARS.jsp	
American Academy of Pediatrics International Services: http://www2.aap.org/nrp/global.html			
Neonatal Resuscitation Program	Hospital staff caring form newborns at delivery	http://www2.aap.org/nrp/about.html	Jointly sponsored with the American Heart Association
Emergency Nurses Association International Information: https://www.ena.org/membership/International/Pages/Default.aspx			
Trauma Nurse Core Course	Nurses providing emergency trauma care	https://www.ena.org/education/ENPC-TNCC/tncc/Pages/aboutcourse.aspx	International courses available
Course in Advanced Trauma Nursing	Experienced emergency nurses	https://www.ena.org/education/catn/Pages/default.aspx	On-line course
Emergency Nursing Pediatric Course	Nurses providing emergency care	https://www.ena.org/education/ENPC-TNCC/enpc/Pages/aboutcourse.aspx	International courses available
Other Organizations			
American Association of Critical Care Nurses Clinical Practice Resource Links	Acute and critical care nurses	http://www.aacn.org/wd/practice/content/clinicalpracticelinks.pcms?menu=practice	Pediatric and neonatal resources
Acute Assessment and Management of Pediatric Trauma	Trauma team members	https://depts.washington.edu/pedtraum/	Harborview Medical Center, Seattle, Washington, USA

AfterPICU.com	Patients and Families following a critical illness	http://www.afterpicu.com/	MAQ Curley, PhD, RN
Marthaaqcurley.com	PICU nurses	http://www.marthaaqcurley.com/	Access to PICU assessment tools such as the Braden Q and SBS
OPENPediatrics	Global community caring for children	http://openpediatrics.org/clinician_resources_category/nurse/	International web-based forum for
Pediatric Delirium website	PICU nurses	http://www.icudelirium.org/pediatric.html	Vanderbilt University Medical Center
PedsCCM Learning ICU Fundamentals course	Targeted to medical residents, appropriate for experienced ICU nurses	http://www.learnicu.org/Fundamentals/RICU/Pages/default.aspx	Supported through the Society of Critical Care Medicine
World Federation of Critical Care Nurses Resource Page	Critical care nurses	http://wfccn.org/resources	
WFPICCS Educational Resources	Global critical care team members	http://www.wfpiccs.org/education/doctors-nurses/documents/	World Federation of Pediatric Intensive & Critical Care Societies
WFPICCS Video Library	Global critical care team members	http://www.wfpiccs.org/education/doctors-nurses/video-library/	World Federation of Pediatric Intensive & Critical Care Societies
WHO Guidelines on Basic Newborn Resuscitation	Healthcare team members assisting with deliveries	http://apps.who.int/iris/bitstream/10665/75157/1/9789241503693_eng.pdf?ua=1	World Health Organization

Table 8-2: Basic Pediatric Critical Care Equipment Listing

Basic Critical Care Equipment/Supplies:

Medications

❍ atropine
❍ adenosine
❍ amiodarone
❍ antiemetic agents
❍ calcium chloride
❍ dextrose (D10W, D50W)
❍ epinephrine (1:1000; 1:10 000 solutions)
❍ lidocaine
❍ magnesium sulfate
❍ naloxone hydrochloride
❍ procainamide
❍ sodium bicarbonate (4.2%, 8.4%)
❍ topical, oral, and parenteral analgesics
❍ antimicrobial agents (parenteral and oral)
❍ anticonvulsant medications
❍ antidotes (common antidotes should be accessible to the ED)
❍ antipyretic drugs
❍ bronchodilators
❍ corticosteroids
❍ inotropic agents
❍ neuromuscular blockers
❍ sedatives
❍ vaccines
❍ vasopressor agents

Respiratory

endotracheal tubes

❍ uncuffed 2.5 mm
❍ uncuffed 3.0 mm
❍ cuffed & uncuffed 3.5 mm
❍ cuffed & uncuffed 4.0 mm
❍ cuffed & uncuffed 4.5 mm
❍ cuffed & uncuffed 5.0 mm
❍ cuffed & uncuffed 5.5 mm
❍ cuffed 6.0 mm ❍ cuffed 6.5 mm
❍ cuffed 7.0 mm ❍ cuffed 7.5 mm
❍ cuffed 8.0 mm

stylets for endotracheal tubes

❍ pediatric ❍ adult

laryngoscope blades

❍ straight: 0
❍ straight: 1
❍ straight: 2 ❍ curved: 2
❍ straight: 3 ❍ curved: 3
❍ laryngoscope handle

magill forceps

❍ pediatric ❍ adult

nasopharyngeal airways

❍ infant ❍ child ❍ adult

oropharyngeal airways

❍ size 0

Vascular Access

arm boards

❍ infant ❍ child ❍ adult

catheter-over-the-needle device

❍ 14 gauge

❍ 16 gauge

❍ 18 gauge

❍ 20 gauge

❍ 22 gauge

❍ 24 gauge

intraosseous needles or device

❍ pediatric ❍ adult

umbilical vein catheters

❍ 3.5F ❍ 5.0F

central venous catheters

❍ 4.0F

❍ 5.0F

❍ 6.0F

❍ 7.0F

intravenous solutions

❍ normal saline

❍ dextrose 5% in normal saline

❍ dextrose 10% in water

IV administration sets

❍ with calibrated chambers and extension tubing and/or infusion devices with ability to regulate rate and volume of infusate

General Equipment

❍ patient warming device

❍ intravenous blood/fluid warmer

❍ weight scale in kilograms (not pounds)

❍ tool or chart that incorporates weight (in kilograms) and length to determine equipment size and correct drug dosing

❍ age appropriate pain scale-assessment tools

Specialized Pediatric Trays or Kits

❍ lumbar puncture tray

- ❍ infant/pediatric 22 gauge needles
- ❍ adult 18-21 gauge needles

❍ supplies/kit for patients with difficult airway

- ❍ supraglottic airways of all sizes

❍ size 1

❍ size 2

❍ size 3

❍ size 4

❍ size 5

suction catheters

❍ infant ❍ child ❍ adult

❍ yankauer suction tip

tracheostomy tubes

❍ 2.5 mm

❍ 3.0 mm ❍ 3.5 mm

❍ 4.0 mm ❍ 4.5 mm

❍ 5.0 mm ❍ 5.5 mm

bag-mask device, self-inflating

❍ infant: 450 ml

❍ adult: 1000 ml

masks to fit bag-mask device adaptor

❍ neonatal ❍ infant

❍ child ❍ adult

laryngeal mask airway

❍ size: 1 ❍ size: 1.5

❍ size: 2 ❍ size: 2.5

❍ size: 3 ❍ size: 4

❍ size: 5

clear oxygen masks

❍ standard infant

❍ standard child

❍ standard adult

❍ partial nonrebreather infant

❍ nonrebreather child

❍ nonrebreather adult

nasal cannulas

❍ infant ❍ child ❍ adult

nasogastric tubes

❍ neonate: 5F

❍ infant: 8F

❍ child: 10F

❍ adult: 14-18F

Monitoring Equipment

blood pressure cuffs

- ❍ neonatal
- ❍ infant
- ❍ child
- ❍ adult-arm

❍ laryngeal mask airway
❍ needle cricothyrotomy supplies
❍ surgical cricothyrotomy kit

❍ tube thoracostomy tray

chest tubes:

❍ infant: 10-12F
❍ child: 16-24 F
❍ adult: 28-40 F

❍ urinary catheterization kits and urinary (indwelling) catheters, 6F–22F

❍ adult-thigh

❍ doppler ultrasonography devices

❍ electrocardiography monitor/ defibrillator with pediatric and adult capabilities including pads/paddles

❍ hypothermia thermometer

❍ pulse oximeter with pediatric and adult probes

❍ continuous end-tidal CO2 monitoring device

Adapted from: The AAP, ACEP, ENA, EMSC National Resource Center, and Children's National Medical Center (2010) Guidelines for the Care of Children in Emergency Department Checklist. Available at: https://www.ena.org/about/position/jointstatements/Documents/GuidelinesfortheCareofChildreninED2010.pdf. Accessed on: 12/2/2015.

Questions/Case Studies

1. A key requirement of all PICUs is:

    a. The ability to provide extracorporeal membrane oxygenation (ECMO)

    b. A nursing and resident fellowship program

    c. Nursing staff skilled in the care of critically ill children who provide close monitoring and surveillance

    d. A transport team

2. A concerning long term effect of a pediatric critical illness is:

    a. Failure to thrive

    b. Decreased cognitive functioning such as problems with attention or memory

    c. Premature onset of puberty

    d. Food aversion

3. Which of the following statements is incorrect?
    a. The Institute for Family-Centered Care was created in 1992.
    b. Respect and dignity, shared information, participation and collaboration are the most important principles supporting patient- and family-centered care.
    c. The term "patient- and family-centered care" shows the importance of involving the family and patient as essential members of the health team.
    d. The philosophy of patient- and family-centered care currently can be found in all health institutions across the globe, and is a focus of health professionals seeking to promote and improve the safety of children in the PICU.
    e. The WHO campaign called "Patient to Patient Safety" revealed the importance of each patient's participation in promoting of their own safety.

Case Study: JP, three years old, was admitted to the emergency room with dry cough often accompanied by respiratory distress and cyanosis of the lips. Pertussis was diagnosed, and the child was admitted to the Pediatric ICU for observation. Care provided, in addition to medications, was the provision of oxygen support as needed for paroxysmal cough, and the provision of comfort to JP, as well as support to JP's parents. JP's mother remained at her son's bedside full time, and did not receive ongoing information from the healthcare team. She became anxious, tearful, and did not feel secure with the care provided by the team. She felt the team did not attend to JP during his moments of crisis (coughing spells). JP's mother did not understand the pathology, treatment and necessary care related to pertussis. In addition, there was no other family member available to provide JP's mother with breaks away from the bedside, and she did not feel comfortable leaving JP alone. JP's father was not able to visit because the visiting hours of the hospital were not compatible with his work schedule.

4. In thinking about the above case, which of the strategies listed below could be used in this unit to promote a careful focus on the child and family?

    1. Consider the mother as an ally in the quest for patient safety and quality of care
    2. Emphasize the role of family as a partner in care and recognize the strengths of JP's mother in the child's recovery
    3. Invite JP's mother to participate in meetings, task forces and discussions involving family-centered care
    4. Make efforts to implement child- and family-centered care in the PICU, including open visitation
    5. Ensure that information updates are provided regularly to JP's mother; assess the effectiveness of the communication
    6. Promote participation by JP's mother's in interdisciplinary team discussions at the bedside

    a) Statements 2, 3, 4, 5, & 6 are correct

    b) Statements 4 and 5 are incorrect

    c) All statements are correct

    d) Only statements I, II, III and VI are correct

    e) Statements 1, 3, 5, & 6 are correct

Case study: Marie is a 6 month old child who has been well up until the past few days. Her mother brings Marie to the clinic because Marie has had a fever for two days, and could not be awakened from her afternoon nap. Your "quick look" assessment of Marie reveals that her tone is floppy, she is not focusing or interacting with her mother or with you, her face is flushed, *and she does not seem to be having difficulty breathing. You obtain the following vital signs: heart rate of 200; systolic blood pressure of 75 mm Hg; respiratory rate of 35, with mild retractions. A thorough assessment of Marie's peripheral perfusion reveals a capillary refill time of 3-4 seconds, feet cool to the touch, and pedal pulses weaker than her femoral pulses. In addition, she is responding only to painful stimulus. When you listen to breath sounds, her respirations are increased in rate, and she does not have rales. The team feels that Marie is demonstrating signs of septic shock.*

5. Which of the following lists the initial interventions for septic shock in the appropriate order?
    a. Initiate high flow oxygen; obtain vascular access; begin a rapid boluses of 20 mL/kg of isotonic saline; reassess heart rate, blood pressure, perfusion, urine output
    b. Initiate high flow oxygen; obtain vascular access; begin dopamine; reassess heart rate, blood pressure, perfusion, urine output
    c. Intubate the patient; obtain vascular access; begin dopamine; reassess heart rate, blood pressure, perfusion, urine output
    d. Initiate oxygen by nasal cannula; obtain vascular access; begin dopamine; reassess heart rate, blood pressure, perfusion, urine output

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Chapter 9

Global Issues in Critical Care Nursing

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Learning Outcomes

After completing this e-chapter you will be able to:

- Understand the history and challenges of creating a critical care global community
- Identify the major themes and issues challenging the critical care community
- Understand the similarities and differences in resources and capabilities of different regions of the world and how this can impact on priorities and choices
- Become familiar with the various global and regional critical care federations of the world, their purpose, scope and activities.
- Examine the different approaches being used to research and understand global issues in critical care.
- Identify the current and proposed global initiatives being lead by various groups to address some of the "big" issues in critical care today.
- Examine the issues confronting critical care in your own situation and explore what you and your colleagues can do, ie Think global, act local!

Definitions

Critical Care Nurse: Critical care nursing is specialised nursing care of critically ill patients who have manifest or potential disturbances of vital organ functions. Critical care nursing means assisting, supporting and restoring the patient towards health, or easing the patient's pain and preparing them for a dignified death. The aim of critical care nursing is to establish a therapeutic relationship with patients and their relatives and to empower the individuals' physical, psychological, sociological and spiritual capabilities by preventive, curative and rehabilitative interventions (WFCCN, 2007).

Critical Care Nursing Organisation (CCNO): A critical care nursing association is an association or society of critical care nurses. Or it is a separate critical care nurses section within a health professional association with its own constitutions, regulations and rules. (WFCCN, 2007).

GDP (purchasing power parity): compares the gross domestic product (GDP) or value of all final goods and services produced within a nation in a given year. A nation's GDP at purchasing power parity (PPP) exchange rates is the sum value of all goods and services produced in the country valued at prices prevailing in the United States. (CIA, 2014)

Chapter Overview

Technological and intellectual sophistication has dramatically changed our world forever. Healthcare advancements in particular have eradicated some diseases and enabled us to save many lives from illness and disease that would once have been futile. Critical care has been a significant player in the healthcare armoury for the last 50 years of human existence and is now consuming a significant proportion of the healthcare cost in many countries. For instance in the USA, the cost of a critical care medicine bed is >$3500 per day, with an estimated cost of $81.7 billion per year for ICU costs overall, representing >13% of total annual hospital costs (Halpern &Pastores, 2010). As a specialty field, critical care is an expanding area of healthcare. The first ICUs were established in the late 1950s and many improvements have been made in terms of technological advances and understanding of the pathophysiology and pathogenesis of the disease processes that affect critically ill patients (Vincent, 2013). Critical care medicine has evolved over the years in terms of structure, process, and outcomes. Improved diagnostics, expansion of the service beyond the physical walls of the ICU, and better national and international collaborations with colleagues across the globe are just some of the many changes that have occurred since the first ICUs were developed some 60 years ago (Weil & Tang, 2011; Grenvik & Pinsky, 2009; Ristagno & Weil, 2009; Vincent, 2013). However for critical care nurses who deliver care to the world's most critically ill people, the issues from their perspective has only recently been captured and shared. In this chapter we explore the perspective of critical care nursing leaders and how they define the most important and significant issues for critical care globally. In short the three major themes remain workforce conditions, education and training and accessibility to useable clinical guidelines and protocols relevant to the context of their practice.

Context has also become an important aspect of these discussions. Recent studies have shown that there are differences in perspective that may be generalized between poor and richer nations. For instance, provision of salary and wages, education and training and access to useable technology remains a significantly important need of nursing in developing and poor countries compared to richer countries, while richer countries want to see the advancement of research programs and addressing significant moral issues such as end-of-life decision making. This chapter explores what the past 15 years of worldwide critical care nursing surveys have informed us about these and other issues that have significance to critical care nurses and to the practice of critical care globally.

Overview

It is self evident that as long as human beings have inhabited this earth, they have been afflicted by critical illnesses, often prematurely impacting their potential life expectancy. However a global view of health care and critical care specifically is a relatively new phenomena. Indeed a truly "global view" has only really been possible in the last 50 years or so. Prior to this, statistics and information were only available in the more developed countries, and even then much of the information was confined to individual countries or well developed regions (Farewell & Johnson, 2010) or groups of countries.

In the early 1950s, the poliomyelitis epidemic inspired the formation of specialist respiratory wards and specialist nurses and doctors to care for the patients afflicted by this condition and later, similar life threatening medical conditions. By the early 1970s as intensive care practices were beginning to specialise, many national critical care medicine societies were being formed. The first World Congress of intensive care medicine occurred in London 1974 and the formation of the World Federation of Societies of Intensive and Critical Care Medicine (WFSICCM) occurred at the 2nd World Congress in 1977, hence establishing the specialty of intensive/critical care as a globally recognised specialty of medicine. During these formative years, intensive and critical care nursing played a less visible but none-the-less important role in forming the speciality that was eventually charged with the responsibility of caring for the hospital’s most critically ill patients in a separate specialised department, Intensive Care.

The development of critical care nursing evolved out of the need for intensive monitoring of critically ill patients. Patients who require critical care treatment are often physiologically unstable, at risk, or in danger of dying. At the same time, intensive care is provided to patients with the expectation for survival. Thus, critical care combines physiological instability with the hope for recovery (Fairman & Lynaugh, 1998). Florence Nightingale was one of the first nurses to advocate for the placement of patient’s requiring “intensive” or large amounts of nursing care close to the nurses desk. This concept evolved over time to the care of critically ill patients, who required direct or more frequent nursing observations (Fairman & Lynaugh, 1998). As a result of the nature of critical illness, patients in intensive care unit settings (ICU) require vigilant nursing care, often with 1:1 or 1:2 nursing to patient ratio’s.

The role of the critical care nurse is essential to the multidisciplinary team needed to provide specialist knowledge and skill when caring for critically ill patients (WFCCN, 2005a). The critical care nurse enhances delivery of a holistic, patient centred approach in a high tech environment bringing to the patient care team a unique combination of skill, knowledge and caring. In order to fulfil their role, nurses require appropriate specialised knowledge and skills not typically included in the basic nursing programs of most countries (WFCCN, 2005b).

The first critical care nursing society was the American Association of Critical Care Nurses (AACN) formed in 1969 and has always been a leader and advocate for critical care nurses in the USA (AACN, 2015). However, many other intensive care nurses in other parts of the world would, and still do, join medical societies or only participate in activities of the medical society that were open to broader participants such as conferences or teaching programs.

Trying to capture and therefore understand the needs of critical care nurses from a global perspective has, until recently, been difficult. Lacking financial, political, communication tools and resources has made international networking and collaboration difficult for many critical care nursing leaders especially those who were eager to participate in collaboration beyond their own country and region.

The oral history of the participation of critical care nurses at the World Congress every 4 years from the 4th world congress in Tel Aviv, Israel in 1985 to the 7th world congress in Ottawa, Canada in 1997, informs us that satellite meetings of critical care nursing leaders at these congresses expressed the need and desire to form a global network to improve communication, collaboration and cooperation beyond the congress, but alas such goals were elusive due to the same limitations identified earlier.

In 2001 at the 8th World Congress of Intensive Care, 44 nursing leaders from 15 countries met in a satellite meeting of the congress and 8 national critical care nursing organisations pre-arranged their representative to “sign up” to the formation of the World Federation of Critical Care Nurses (WFCCN) and so started a movement that would ultimately help to identify and respond to issues concerning critical care nurses globally.

An Approach to Defining Global Issues from a Critical Care Nursing Perspective

Prior to the formation of the WFCCN, a small team of colleagues who had met at the World Congress in Ottawa in 1997, agreed to conduct a survey that would be sent to all known critical care nursing leaders in the world using a snow-balling method to capture as many participants from as many countries as possible through personal contacts and acquaintances.

The first worldwide survey of critical care nursing organisations and nurses was designed to:

- Identify as many critical care nursing organisations from as many countries as possible and obtain their details.
- Identify the relative importance of 14 issues for critical care nurses in their countries. These issues had been pre-identified by an expert panel of critical care nursing leaders

using a modified Delphi technique. The respondents were also asked to expand their comments in free text with respect to the 3 most important issues they identified.

- The third section of the survey asked respondents to identify the services that CCNOs provided to members and to rank the importance of these issues whether provided or not in their country
- The final section explored the feasibility and purpose of an international network of critical care nursing organisations, which was eventually agreed and formed under the umbrella of WFCCN. (Williams et al., 2001)

Similar surveys asking similar questions have been conducted in 2005 (Williams et al., 2007), 2009 (Williams et al., 2012) and 2013 (Williams, Fulbrook, Kleinpell, Schmollgruber & Alberto, 2015).

Results

Over the last 4 worldwide surveys of critical care nurses, a number of interesting trends and discoveries have occurred.

The total number of countries represented in each survey are summarised in Table 1.

Whilst these results only represent a fraction of all world countries, they generally represent the populous countries of the world and in recent times have represented a far more diverse profile of countries than at the start.

The most important issues over the 4 surveys have been summarised in Table 2. The final two columns of Table 2 represents the overall rank order of the issues over time with the issue having the lowest score being the one that has most consistently ranked most important over the 4 X 4 year surveys conducted thus far. The top 5 issues for critical care nurses over this time have consistently been staffing levels, access to education programs, working conditions, teamwork, provision of formal practice guidelines and competencies.

The results of the 2013 survey were analysed using relative wealth of the countries participating (Williams et al., 2015). Categorization was based on the respondent's national gross domestic product (GDP) and per capita purchasing power parity (CIA, 2014). The low-income group were determined to be those countries whose GDP per capita was ranging from $US 400 to $US 5800 (CIA, 2014). Middle-income countries were those with GDP per capita between $US 5800 and $US 18600, with high-income countries were between $US 18600 to $US 62400. (Table 3)

Table 4 shows the relative importance of issues as determined by respondents from different wealth groups. This particular study in 2013 demonstrated that we could no longer consider global issues as homogenous across the world…. *In fact we should never have made such an assumption in earlier studies*! Previously we had analysed issues by region of the world that showed relatively few, if any, significant differences in issues for critical care nurses. However, when analysing issues for critical care nurses in this latest 2013 study significant differences were noted between relative wealth groups. For instance when analysing the most important issues for critical care nurses high-wealth countries scored less than the overall mean score for all issues discussed, and low-wealth countries ranked all issues higher than the overall mean. In addition using ANOVA with post hoc tests to compare scores between wealth groups, high-wealth countries had statistically significant lower scores compared to middle- and lower-wealth countries regarding access to educational programs, wages, use of technologies, and relationships with doctors. Lower-wealth countries ranked facilities and equipment statistically more important than other groups (Williams et al., 2015).

The authors in the 4th survey noted that "what is important and appropriate to nurses in a wealthy country often does not apply to those in poorer countries and international organizations such as WFCCN need to be mindful that they do not become 'professional colonials' by imposing the opinions and values of one group (rich) onto another (poor) (Williams et al., 2015).

Therefore, caution must be used when making sweeping generalisations regarding the importance of issues globally to critical care nurses as subtle differences do occur especially between rich and poor.

Discussion

The following discussion will focus on the 5 most consistently identified issues for critical care nurses as shown in Table 2 and the points of difference between richer and poor countries as shown in Table 4.

1. Staffing levels

The findings suggest that there is a consistent global concern related to a health care workforce shortage and this issue is expected to become worse in the coming decade (World Health Organization, 2013). From time to time concern for staffing levels has been overshadowed by a relative nursing over supply commonly seen during economic downturn and recession (Staiger, Auerbach, & Buerhaus., 2012). However our survey has previously been sensitive to the global nursing workforce issues in 2001 and may well be predicting the commencement of an emerging critical care nursing shortage is again in 2013 (Williams et al., 2015).

There is a clear need for sophisticated workforce planning at the local, national and international level. Mechanisms are needed to help inform policy makers and governments to pre-empt and plan for shortages and to manage over supply carefully to ensue relative equilibrium across the system. At a macro-level international efforts to stabilize nursing generally are being led by many although specific actions for specialties such as critical care are not recognized specifically.

2. Working conditions (including wages)

In the most recent study working conditions were rated first, staffing levels (3rd) and wages (6th) most important ranked issues (Williams et al., 2015). Workforce and working conditions are also areas of strong concern for many nursing leaders around the world (Buchan, O'May, & Dussault, 2013; De Córdova et al., 2013; Staiger, Auerbach, & Buerhaus, 2012) although in our survey wages per se were significantly less important in countries with higher incomes. It would appear that wages are important but other factors like staffing ratios, workloads and family friendly roster schedules are also important factors for critical care nurses.

Again we found wealthy countries had significantly less concern for appropriate wages and technology while poorer countries were significantly more concerned for the standard of facilities and technology in their countries. Intuitively, this is not surprising but as the authors concluded ‘one size does not fit all’ and this needs to inform the approach of international organizations such as WFCCN and others. High-income countries offer better remuneration, professional advancement and career opportunities, and a safer working environment than low-income economies (Aluttis, Bishaw, & Frank, 2014; de Mesquita, 2005) these matters may also influence the overall perceptions of working conditions.

3. Access to education programs and competency training

The WHO emphasizes that the increasing complexity involved in providing healthcare and the need to ensure more equitable access to health care now mandate the need for global standards for nursing education and practice (World Health Organization, 2009).

Access to education programs has remained an important issue in all countries and one of the most common free text discussion points in all surveys conducted by our teams. However, as with wages, it was evident that the provision of quality education programs was significantly less important among the high-income countries compared to others. This may be attributed to the improved provision and access to educational programs in the wealthier countries, especially through online/ internet access highlighted in earlier surveys (Williams et al., 2012). CCNOs and nursing leaders in countries with low incomes will need to find appropriate and affordable ways to improve access to quality education programs. Developing awareness of this need through the networks of WFCCN and other global organizations may provide an opportunity for the wealthier countries to collaborate and raise support to assist their colleagues in poorer countries. In regards to education, WFCCN and other international nursing and health care organizations may have an instrumental role to assist developing countries to work from similar clinical guidelines that could be taught through education and training programs or made accessible via the internet or through other means.

4. Teamwork

This issue has been difficult to interpret and needs to be examined more deeply. In our surveys, the respondents indicated that their relationship with doctors and with other professions was a low priority compared to other items. The fact that many respondents identified "teamwork" as an issue of high importance has been interpreted that critical care nurses value the collaborative relationships they have with doctors and other health professionals. Occasionally these relationships are strained (Roy & Brunet, 2005; Papathanassoglou et al., 2012) but the survey findings in our studies suggest that valuing these relationships and creating a collegial and supportive work environment will benefit all, including the patients (Cabrini et al., 2015). The importance of strong collaborative teamwork in the critical care environment has been well described elsewhere (Alves & Mello, 2006; Coombs, 2003; Karanikola et al., 2014; Manley, 2008).

5. Provision of formal practice guidelines and competencies

Provision of formal practice guidelines and competencies has remained an important issue for critical care nurses globally and this was a consistent theme regardless of region or wealth (Table 2). It is reassuring that critical care nursing leaders are highlighting this need at this time as safety, quality and error prevention remain important critical issues in clinical practice throughout the world (Latif, Rawat, Pustavoitau, Pronovost, & Pham, 2013; Valentin, Schiffinger, Steyrer, Huber, & Strunk, 2013). However, our studies found that many CCNOs were not providing guidance in this area. There is a danger that when professional guidance is unavailable nurses may turn to the most accessible source of information, such as the Internet. Although there is a wealth of material available via this medium, much of it is unregulated (Harris et al., 2015). Online education forums, practice standards and consensus papers can be found on many websites if individuals have Internet access and know how to search and find them. In response to the need to identify online educational resources, WFCCN has worked to identify internet based resources for critical care nursing including a topical index of web based resources for critical care nursing education which is available through open access on the WFCCN website, as well as to guide current work to this e-book for critical care nursing practice.

The very active text responses to what WFCCN and other leaders ought to provide in terms of policy and practice guidelines remain strong and relatively consistent over the last 4 surveys. Clinical protocols, workforce and education standards, and clinical practice guidelines for common encountered challenges including but not limited to: pediatric conditions, tracheostomy management, weaning from ventilation, sepsis management, pain and sedation management, delirium management, and the workplace environment, suggests WFCCN remains a relevant and important vehicle for the continued leadership of critical care nursing practice standards globally. However, it is also clear that huge gaps between what is required and what exists remain and the nursing leadership and policy makers of health systems throughout the world need to find efficient and effective collaborative ways to meet these needs collectively. Awareness of the needs of the profession becomes crucial for global leaders so they are able to better understand and advocate for critical care nurses and services more effectively. This book and many others like it attempt to address this ongoing need.

Future Directions

As stated in earlier studies “one size does not fit all”, although we have found global trends and consensus in terms of workforce and education needs as well as provision of guidelines to inform critical care nursing practice, the specific needs and priorities of richer and poor countries need also to be acknowledged and responded to. Greater sophistication of the studies previously conducted by our team need to be developed and repeated more regularly at the regional, national, state/province and hospital level. Ensuring that the issues we are reviewing, responding to and developing standards for are relevant and necessary to the specific audience is critical.

Ideally there could be an online annual survey of a large database of critical care nursing managers and clinicians throughout the world and throughout each country to inform the priorities and issues of the profession. Such a database could then be used to distil the precise audience and questions that need to be answered, reviewed and updated regularly.

May the WFCCN regional structures such as Latin American Federation of Intensive Care Nurses (Williams, Alberto, Gonzales De la Cruz & Domínguez Martínez, 2015), European Federation of Intensive Care Nurses (EfCCNa, 2007) and the Asia Pacific Federation of Critical Care Nurses (Hong Kong Association of Critical Care Nurses, 2003) be the instruments for further provision of guidance, collaboration and local support that will empower nurses to identify and face critical issues more effectively. Critical care practice today demand a practitioner with the ability to think/connect globally and act locally. National critical care organizations and regional structures can help to meet these expectations.

In addition, the broader questions of "what issues ***should*** critical care nurses be interested in" will be informed by other research studies into patient outcomes AND "what issues would ***patients and their families*** want critical care nurses to be more interested in" are definitely on the list of future directions for global issues research.

Conclusion

As a specialty area of nursing care, critical care nursing continues to expand as intensive care is provided beyond the walls of the traditional ICU setting, based on the changing nature of critical illness, which can occur in all healthcare settings, including the home care setting. Additionally, telemedicine is a growing field for critical care, with significant implications for critical care nurses (Kleinpell et al 2016). Ongoing advances in critical care require continued focus on ensuring that critical care nursing practice evolves to meet current and future needs on an international level. As identified in ongoing international critical care nursing surveys, clear and consistent themes in terms of the global issues in critical care nursing remain relatively unchanged over the last 15 years: Workforce staffing and conditions, access to quality education programs and clinical practice guidelines and competencies are the three most consistently raised themes. Through the use of journals, conferences, text books, collaboration within regional bodies and many other medium there is evidence that many of the informational needs of nurses are now addressed with the latest evidence available online if the nurses is orientated to how best to retrieve and read such information.

Major barriers to such information appear to be wealth status and language. Ensuring easy access of these resources to critical care nurses in poorer countries and to those who only read and understand non-mainstream languages is the next great hurdle for the critical care nursing profession to overcome. Through the ongoing efforts of WFCCN and related bodies committed to the betterment of critical care practice globally, critical care nursing will continue to evolve to meet the needs of acute and critically ill patients worldwide.

Questions

(Correct answers follow)

1. What is the average daily cost to run an intensive care bed in the USA?

    A. $1500

    B. $2500

    C. $3500

    D. $4500

2. The first ICUs as we know them today can be traced back to when and for what reason?

    A. 1930s and the impact of the Great Depression.

    B. 1950s and the outbreak of poliomyelitis.

    C. 1960s and medical technology advances from the Korea and Vietnam wars.

    D. 1970s and the establishment of AACN and the WFSICCM.

3. The WFSICCM and WFCCN were established in which years respectively?

    A. Both groups have existed in various forms since 1950s.

    B. WFSICCM in 1977 and WFCCN in 2001.

    C. WFSICCM in 1969 and WFCCN in 1977.

    D. WFSICCM and WFCCN were established together in 1977.

4. Who first advocated for the placement of patient's requiring "intensive" or large amounts of nursing care close to the nurses desk?

    A. Queen Victoria of England in the 1840s.

    B. Florence Nightingale in 1850s during the Crimean war.

    C. Marianne Cope, founder of first Catholic Hospitals in New York, 1870s.

D. Agnes Hunt in 1918 after winning the Red Cross Medal for services during the Great War.

5. The WFCCN Declaration of Madrid (2005) describes:

   A. Is a position statement on the provision of critical care nursing education.

   B. Is a position statement on the provision of critical care workforce.

   C. Is a position statement of the critically ill patient.

   D. Is a position statement on culturally appropriate care provision in the critical care environment.

6. The WFCCN Declaration of Buenos Aires (2005) describes:

   A. Is a position statement on the provision of critical care nursing education.

   B. Is a position statement on the provision of critical care workforce.

   C. Is a position statement of the critically ill patient.

   D. Is a position statement on culturally appropriate care provision in the critical care environment.

7. Which of the following issues is ranked consistently the most important for critical nurses in the last 15 years?

   A. Education and training.

   B. Salary and wages.

   C. Teamwork.

   D. Staffing levels.

8. Critical care nurse respondents from high wealth countries tend to rank which of the following issues significantly less important compared to low and middle-income countries.

   A. Access to education programs.

   B. Wages.

C. Use of technology.

D. Relationship with doctors.

E. All of the above.

9. Critical care nurse respondents from low-income countries tend to rank which of the following issues significantly more important compared to high and middle-income countries.

   A. Access to education programs.

   B. Wages.

   C. Facilities and equipment.

   D. Relationship with doctors.

   E. All of the above.

10. Access to formal practice guidelines and competencies is an important issue to many critical care nurses and was ranked X in the 2013 survey by Williams et al, where X =?

   A. Second, behind Staffing levels.

   B. First.

   C. Equal third with education and training provision.

   D. Trick question, it is not an important issue.

Answers

1. C

2. B

3. B

4. B

5. all

6. B

7. D

8. E

9. C

10. A

Table 9-1: Comparison of number of countries responding to the surveys, by region (Williams et al., 2001, 2007, 2012, 2015)

Region	2001	2005	2009	2013
Europe	13	22	26	15
Americas	3	10	13	13
Asia	8	11	12	11
Africa	0	7	7	14
MiddleEast	0	1	7	6
Total	24	51	65	59

Table 9-2: Comparison of overall ranking of importance of issues to critical care nurses over time (Williams et al., 2001, 2007, 2012, 2015)

Issue	**2001**	**2005**	**2009**	**2013**	**Total Ranking Score**	**Overall Ranking**
Teamwork	8.3 (7)	8.9 (2)	9.2 (1)	9.30 (5)	15	4
Staffing levels	9.2 (1)	8.9 (1)	9.0 (2)	9.36 (3)	7	1
Access to educational programs	8.8 (3)	8.6 (3)	9.0 (3)	9.34 (4)	13	2
Formal practice guidelines/competencies	8.4 (5)	8.3 (6)	9.0 (4)	9.45 (2)	19	5
Working Conditions	8.9 (2)	8.6 (5)	8.9 (5)	9.46 (1)	13	2
Work activities/roles	8.3 (6)	7.9 (8)	8.7 (6)	9.05 (7)	27	6
Extended/advanced practice	7.9 (8)	7.7 (11)	8.7 (7)	9.04 (8)	34	8
Relationship with doctors	7.8 (9)	7.8 (10)	8.5 (8)	8.79 (12)	39	10
Relationship with other nursing groups	6.9 (13)	7.6 (12)	8.5 (9)	8.71 (13)	47	13
Facilities and equipment	7.2 (12)	8.1 (7)	8.4 (10)	9.02 (9)	38	9
Use of technologies	7.4 (11)	7.9 (9)	8.4 (11)	8.91 (10)	41	11
Formal credentialing process	7.6 (10)	7.6 (13)	8.3 (12)	8.88 (11)	46	12
Wages	8.5 (4)	8.6 (4)	8.0 (13)	9.27 (6)	27	6

Relationship with other health care groups	6.8 (14)	7.5 (14)	7.9 (14)	8.61 (14)	56	14

Table 9-3: Categorisation by region and relative wealth involved in 4th worldwide survey of critical care nurses (Williams et al., 2015)

		World wealth group			Total
		Top third	Middle third	Lower third	
Region	Europe	12	3	0	15
	Middle East	4	2	0	6
	Africa	0	3	11	14
	Asia	7	1	3	11
	The Americas	4	7	2	13
Total		27	16	16	59

Low income = $400 - $5,800 (USD)
Middle Income = $5,900 – $18,600 (USD)
High Income = $18,700 – $64,000 (USD)

Table 9-4: Comparison of issues important to critical care nurses by wealth group (Williams et al., 2015)
* p<0.05

Descriptive Statistics

	World Wealth Top third	World Wealth middle third	World Wealth Lower Third	World	Range	Std. Deviation
Working conditions	9.28	9.33	9.88	9.46	7-10	.934
Formal practice guidelines/ competencies	9.16	9.60	9.75	9.45	6-10	.989
Staffing levels	9.13	9.24	9.75	9.36	5-10	1.052
Access to quality educational programs	8.84*	9.60	9.81	9.32	5-10	1.130
Teamwork	9.16	9.25	9.60	9.30	2-10	1.439
Wages	8.76*	9.53	9.81	9.27	6-10	1.087
Extended/advanced practice	8.80	9.20	9.31	9.05	5-10	1.212
Work activities/roles	8.56	9.40	9.50	9.05	6-10	1.285
Facilities and equipment	8.68	9.00	9.69*	9.05	6-10	1.197
Use of technologies	8.44*	9.20	9.50	8.95	5-10	1.257
Relationships with doctors	8.32*	9.06	9.47	8.84	5-10	1.304
Formal credentialing processes	8.24	9.06	9.53	8.84	3-10	1.703
Relationships with other nursing organisations	8.44	9.00	9.07	8.77	4-10	1.584
Relationships with other health care groups	8.40	8.50	9.27	8.66	4-10	1.456
Valid Responses = 56						

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Chapter 10

Family Centered Care

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Introduction and Chapter Objectives

This chapter will review definitions of family and family centered care, post-intensive care syndrome-family (PICS-F), and essential elements of a program of family centered care (FCC) within the context of biomedical ethics. Two different theoretical models are used to explore the application of family centered care to practice: Joanne Duffy's Quality Caring Model, and Judy Davidson's Facilitated Sensemaking Theory. A leadership strategy for quality monitoring of a program of FCC will be presented. Where applicable, global variation in practice is highlighted. The chapter will conclude with a first person testimony from one author who served as a family member of a critically ill infant illustrating how applying FCC can work in practice.

Definitions

Family

Family is defined in many ways by various professional organizations. The Society of Critical Care Medicine adopted the definition of family published by the National Consensus Project for Quality Palliative Care:

> “Family is defined by the patient or in the case of minors or those without decision making capacity by their surrogates. In this context the family may be related or unrelated to the patient. They are individuals who provide support and with whom the patient has a significant relationship” (J.E. Davidson et al., 2007; "National Consensus Project for Quality Palliative Care: Clinical Practice Guidelines for quality palliative care, executive summary," 2004).

The Institute for Patient and Family Centered Care defines family as “….two or more persons who are related in any way—biologically, legally, or emotionally. Patients and families define their families” ("What is patient-and family-centered care?," 2011). The common premise is that family is determined by the patient and may include those who are not relatives or spouses. Adhering to principles of biomedical ethics, as healthcare providers we have an obligation to respect the decision of the patient as to who constitutes family and not challenge those that present themselves as ‘family’ of the patient.

Family Centered Care

Several terms are used to reflect the type of care provided which is inclusive of the patient/family unit: patient centered, patient and family centered, and family centered care, published without consistency with and without hyphens between the words. For the purposes of this chapter, because the focus is on family, the term family centered care (FCC) is used. The key to FCC is that it is a mutually beneficial relationship between healthcare providers, families and the patients. Family centered care transcends merely including families in care, or allowing their presence and moves towards true collaborative relationships. Family centered care flattens the bureaucracy of healthcare so that families may, when desired, serve on equal grounds to provide care, participate in decision-making and collaborate on the best approaches to obtain optimal wellness or dignified death in the best interest of the patient. Family centered care acknowledges that the social, emotional and in the case of children, developmental support are just as important as the physical care or treatments rendered. Family centered care hinges on the premise that the integrity of the family unit is protected by preserving dignity and control whenever possible. ("What is patient-and family-centered care?," 2011). Core tenets of family centered care include developing bi-directional relationships built from respect, the sharing of information, presence, participation and collaboration (J.E. Davidson et al., 2007; Neff et al., 2003; Shields et al., 2012; "What is patient-and family-centered care?," 2011).

When reviewing the qualitative literature regarding family needs a message also rises to the surface. Families need us to help them either bond and become a family, in the case of newborns, or adapt and cope and maintain family integrity in the case of children or adults experiencing critical illness (Eggenberger & Nelms, 2007; Fenwick, Barclay, & Schmied, 2000; Meyer, Ritholz, Burns, & Truog, 2006).

The provision of FCC nearly dictates the need for relationship building. The family is not an 'extra' part of the care, or something you pay attention to if you have time, or above and beyond the responsibilities of the nurse. The patient and family are an inseparable unit and need each other to optimize health and wellness. The family is part of the nurse's duty of care, not an aside. Relationship building with the family is just as important as gaining the trust of the patient. In critical illness, the family often serves as the surrogate for the patient, and only by engaging in relationship building with the family will the nurse be able to get to know the patient. This is particularly important when the patient is starting to recover. Recovering ICU patients make reference to losing their sense of identity, and perceive family and friends as critically important in helping maintain a sense of self, (Logan & Jenny, 1997) They also perceive that family and friends assist them to make sense of their surroundings and communicate more effectively (Magnus & Turkington, 2006).

How exactly does the nurse provide care while building these relationships within the context of a time-pressured environment?

The nurse's role in provision of FCC will be described as applied through two theoretical frameworks: Joanne Duffy's Quality Caring Model and Davidson's Facilitated Sensemaking Theory which was designed to describe how to provide family care in the ICU. The examples and vignettes used in this chapter are not contrived. They have been generated from actual clinical experiences and/or research interviews or observations. Each section provides examples to help the learner apply and synthesize the contextual knowledge. Questions are posed intentionally to engage the learner in critically thinking through the concepts of study as they progress and build upon one another.

Post Intensive Care Syndrome-Family

Family centered care is needed to prevent or minimize Post-Intensive Care Syndrome-Family (PICS-Family). Post-intensive care syndrome is defined as new or worsening impairments in physical, cognitive, or mental health status arising after critical illness and persisting beyond acute care hospitalization. The term could be applied to a survivor (PICS) or family member (PICS-F) (Needham et al., 2012). The lay explanation of PICS-F is provided: You or other family members may have new problems that start in the ICU and linger after discharge that may affect the body, thoughts, feelings or mind (J.E. Davidson, Hopkins, Louis, & Iwashyna, 2013). At least one third of family members of critically ill patients will experience anxiety, depression, and symptoms of post-traumatic stress months after discharge or death (Kentish-Barnes, Lemiale, Chaize, Pochard, & Azoulay, 2009; Siegel, Hayes, Vanderwerker, Loseth, & Prigerson, 2008). Others suffer from complicated grief. It is known that how we communicate and the way that we communicate can either help the family through a critical illness or cause harm (Siegel et al., 2008). The family response to critical illness may be partially modulated by our care. Tending to the family while caring for the patient is more than a matter of optimizing satisfaction as a business objective; it is instead a duty to do no harm. The exact mechanisms of how families are injured in the process of exposure to critical illness are not well known. However, models of care to minimize the stress and stress response have been proposed. These models universally include fostering the development of caring relationships, optimizing communication, sharing in decision-making and family engagement in care.

Figure 10-1: An updated model for PICS-F. Adapted from Needham et al., 2012.

The family is exposed to critical illness and may develop anxiety, depression and symptoms of post-traumatic stress which may last many years following the discharge or death of the patient. Bereaved family members may also experience complicated grief also known as persistent complex bereavement disorder which persists longer than six months following a death. The symptoms may include social isolation, suicidal ideation, maladaptive behaviors or thoughts about the person who died or the death experience (*Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition*, 2013). Approximately half of discharged patients will need caregiving after discharge (Desai, Law, & Needham, 2011; Herridge et al., 2003; Wunsch et al., 2010). For these families, the responsibilities may result in caregiving burden. Most families are not prepared for the burden of providing care at home ("Family Caregiving," 2011) . Caregiving burden can exacerbate psychological symptoms previously triggered in the ICU setting and result in physical and emotional fatigue. For older adults fatigue and inability to provide care at home are magnified and may result in institutionalizing the discharged patient, fracturing the once stable family unit. Some family members will experience financial strain from missed work, financial collapse of the household due to loss of patient or family income, fractured family dynamics (divorce, estrangement) due to intra-family conflict or strain from dealing with the responsibilities of caregiving. Even though these long-term caregiving outcomes occur post-discharge, ICU caregivers have an obligation to set families up for as successful a transition home as possible while they are still within our care. In the following sections specific examples will be given of how to protect the health and well-being of the families of critically ill patients.

Joanne Duffy's Quality Caring Model

Joanne Duffy's model of Quality Nursing Caring (Duffy, 2013) presents a modern approach to providing holistic care in a relationship-based model grounded in the understanding of the demands for our time. The core of the model depicts the importance of strong and healthy relationships first in the community and then within the context of a healthcare experience.

People normally live in communities and have human relationships within those communities. Positive relationships in normal life can promote positive and healthy lifestyles. When people experience uncaring relationships or negativity they are less likely to care for themselves. Illness may result. When they can no longer care for themselves, they have professional encounters with the healthcare system and team. In the most stressful of these, the patient and family experience critical illness. If the encounters with healthcare providers during critical illness are positive the recipient of care feels cared for.

Feeling cared for, in turn, generates feeling empowered, whole, valued, worthy, human, supported, encouraged, appreciated, connected, engaged, and hopeful. Feeling cared for also generates a feeling of being understood, known, safe, secure and protected. These outcomes of feeling cared for help to provide the patient and family with the energy and initiative to move forward through illness towards health. In the context of critical illness, helping the family to feel cared for can generate the energy, strength and motivation to navigate through the experience either towards health or a dignified death.

Understanding the limited strength of those in crisis, the duty to help the family feel cared for could serve as a buffer to maintain the strength necessary for caregiving later. It is known that up to 50% of ICU patients will require caregiving support from their families up to a year following the hospitalization. However, Duffy cautions that these caring experiences do not occur in a vacuum. If one nurse in a unit is kind and caring to family members, and another is not, the net result can produce a negative effect which reaches past the individual nurse/patient/family relationship. Even though each nurse has their own assignment, their work, energy attitudes and behaviors add up into relationships and teamwork. Further, it is not enough for a single nurse to be ‘good’ to their own patient and their family. If nurses are not kind to each other it can have a negative effect on the environment that spills over into what is experienced by all others within the environment.

We need to have healthy relationships with each other as nurses and with the other members of the healthcare team to be able to provide care to the patients and their families (Figure 2). Think of a situation where the people working together that day do not get along, and the tension is felt throughout the unit during the whole shift. Do these warring nurses easily ask each other for help with turning and lifting or break coverage? Or do they instead avoid each other, at times neglecting the needs of the patient and family in the process? What about a situation where the nurse and physician do not agree on the plan of care? Can the family help but notice and be affected by these tensions? The family is already of fragile psychological health due to the crisis they are enduring. The added tension in the environment may actually cause these at-risk family members harm. Duffy explains the importance of spending the time to create a healthy work environment that will then support caring in a manner that will optimize healing of the patient and family. Creating a healthy work environment is strongly endorsed by the American Association of Critical Care Nurses ("AACN's healthy work environment's initiative," 2005). Many references are available at www.aacn.org to assist teams improve the healthy nature of the work environment.

According to Duffy, three forms of relationships between, a) nurses, b) nurses and other professionals, and c) professionals and patients and families, are developed contingent upon eight essential factors. These factors include:

- basic human needs
- the healing environment
- appreciation of unique meanings
- encouraging manner
- human respect
- attentive reassurance
- problem-solving
- affiliation needs

So how does this relate to ICU nursing? To follow, each of these 8 factors will be explored with examples relevant to critical care nursing and FCC. With each of these factors we need to consider the triad of relationships: nurse/other professionals/and patients and families.

Basic Human Needs

As nurses we need to tend to our own basic human needs to be able to tend to those of others. Is everyone on shift getting their breaks? How does this relate to FCC? Without breaks would we have the patience to answer the same question from the family that has been asked by fifteen others before? Further, is an issue from home clouding our minds preventing us from authentic caring at the bedside? Tending to our own needs is essential to build the resiliency, focus, clarity and authenticity to provide for others. In FCC, there is a natural tendency for families to feel the need to safeguard during illness. Once they have watched the nurse give attention to the basic needs of the patient it will help them to develop trust that the best of care is being provided. After trust is formed, the need to safeguard will be less intense. Consider this example experienced during a research interview. When asked, "Is there anything more that I can do for you given what you are going through?" the family responded ''Yes, my mom's tubing says *change Tuesday* and it is Wednesday. Shouldn't it be changed?'' The family member was referring to a tag on the ventilator tubing, and had been ruminating about it all morning. As soon as the respiratory therapist was called to change out the circuitry, she visibly calmed down. In another situation after the same question about further needs was asked, the family remarked about a bloody bandage that was on her mom's chest. After investigating, the researcher found that it was a clear bandage with betadine soaked gauze underneath. The family members, in this crisis, look at our care critically, not to blame, but instead because of their human inherent need to safeguard (Burr, 1998; J. E. Davidson, Daly, Agan, Brady, & Higgins, 2010a). With limited knowledge of critical care, they often make false assumptions or place false importance on small tasks. However, instead of battling over what is important and what isn't, it is most productive to take care of what families are focused on so that they can develop trust and feel safe.

The Healing Environment

The environment should be managed to be as calm, caring and supportive as possible. This may be seen in unusual ways. Consider the active intention to optimize alarms to reduce noise. For instance, is the heart rate alarm for the patient whose heart rate is controlled on beta blockers to a rate of 48 set below the normal resting rate? In most ICUs this would have to be an intentional act because the default low heart rate alarm is set between 50 and 60. On the surface it is not obvious that attending to these details are acts of kindness or caring. The impact of not adjusting the alarms is to unnecessarily startle the family every time that they ring. Think about how many times you've been approached by family members because an alarm was ringing, only to say something to the effect of 'that one's not important'. If it is not important, should it be adjusted? Being thoughtful in our approach to individualize the care to each unique situation is indeed an act of human caring. When we care enough to tend to the details through acts like these we create the optimal healing environment.

Providing care in a transparent way by talking through actions out loud helps family members follow your thoughts and learn how you are prioritizing care. Think of this relationship building as akin to precepting. When training a new nurse it helps if the preceptor thinks out loud. The orientee then learns how decisions are made through the thought process of the preceptor. This method of learning is just as effective for the family, many of whom are new to critical illness. It cannot be assumed that they will understand why you are doing what you are doing simply because they are watching. "I am clipping this tubing to your gown and straightening it out so that it doesn't kink. This will make it more comfortable for you. Looks like your kidneys are working better now. We're getting more than 30cc/hr of urine. That's an improvement. How about a pillow under your calves so that your heels don't touch the bed?." Listening to you explain your thoughtful actions puts caring into the air, soothing the environment and making it feel safe to the family who wouldn't otherwise know what was happening.

Appreciation of Unique Meanings

Appreciating unique meanings refers to understanding the patient's cultural and religious needs, their values and preferences. To understand and appreciate the dynamic of difference, it is important to know the same things about yourself and those on your team. By understanding our own values it will be easier to detect when the patient or family's values differ. Our natural default is to provide the care to others that we would want for ourselves. After years of caring for patients at the end of life, I thought it would obviously put the family at ease if I explained that I would be giving morphine to make sure the patient wasn't having any pain. I was taken aback by the response. The son said, 'No, you can't. Don't give him that. He wouldn't want it now.' I had at first thought the son wanted his father in pain. After further investigation it became clear that the family was Muslim and in their faith the father was supposed to say the Call to Prayer as he left this life on earth. Sedated on morphine, the son feared we would take away his only chance to meet that spiritual obligation. When a family interaction triggers the thought, 'Why did he respond that way' or 'I wouldn't have felt that way', this should in turn trigger an evaluation of what values, preferences, cultural or spiritual needs are different in this person or family from your own.

Understanding and accepting the needs of unique family units is also part of providing FCC. Nurses will encounter families where the family structure is already tense, such as in divorce or separation. The patient who is the husband may be visited by the wife and his girlfriend. People may present themselves as 'cousins' or 'children' who have no biological relationship. Often they do this to ensure that they will be allowed in as visitors. With the global recognition of an open definition of family, our nursing duty then is to accept that these people have chosen each other as family and tend to them equally and without judgment. If they have the ties to call each other family, then they will also have the same emotional needs as those who are biologically related or related by traditional marriage.

Attending the unique cultural needs of family members is as simple as asking what the needs are. Questions such as "If you were in your home country, what would you be doing now that we are not doing here? Is there a tradition that we can help you with?" Spiritual needs are similar. The question to ask might be, “Is there a spiritual advisor that I can contact for you to help you through this situation? Would you like me to contact our chaplaincy service for you? Did you know that we have a chapel on the first floor? If you need a quiet place to reflect, it is open all day and night." Through research at a faith-based hospital it was found that even though there was a 15 foot statue of Jesus in the lobby right in front of the chapel, family members in crisis would walk past it every day without thinking that it might be in front of a chapel. They didn’t know that they could ask for a chaplain. The obvious escapes families in crisis, and as part of FCC, we can help them to see the resources around them to help them meet their needs. Nurses often question whether it is appropriate to pray with family members. Prayer is a deeply personal experience. If a family member wants to pray and makes that known, it is within the realm of nursing to minister to that need. In the 2007 Society of Critical Care Medicine guideline for FCC, prayer is recognized as an inter-professional intervention when requested by the patient or family and not conflicting with the professional’s own values. If the nurse is requested to pray and this conflicts with his or her own values the next action would be to find a health professional, spiritual guide or chaplain who would fulfill this need for the family. Often when families request a nurse to engage in prayer, the family member will actually start the prayer and say their thoughts out loud hoping for the nurse to engage with them quietly listening in solidarity or by holding hands.

Encouraging Manner, Human Respect, Attentive Reassurance

Duffy reminds us that it is important to demonstrate respect for, encourage and reassure each other during our work relationships. This in turn will allow us to do the same for the patients and their families. Respect, encouragement and reassurance in professional relationships can take the form of debriefing together after critical incidents. Recently a body of knowledge has formed surrounding the concept of second victim syndrome. Second victim syndrome is defined as feeling victimized by experiences in the work environment. This may include feeling like you’ve failed the patient, decreased self-efficacy, and self-doubts about career choice (Scott et al., 2009; Scott et al., 2010; Seys et al., 2013). To minimize the impact of second victim syndrome providers are encouraged, as Duffy advocates, to help each other take a time out after a negative outcome or adverse event has occurred. Find solace through talking through the situation with others that you trust. Help the person going through the situation take a break before entering back into providing care. Feeling like a victim at work can also occur because of being exposed to situations that remind us too much of something a friend or family member might have gone through. For example, for this reason it would be appropriate to allow a nurse to decline an assignment of a patient who has the same terminal cancer her husband was recently diagnosed with.

Once these acts of encouragement, respect and reassurance are routine within and between healthcare providers, we are better suited to do the same for the families within our care. Recovering from critical illness is not a linear event. Families will need constant reassurance during times when it seems as though progress is one step forward and two steps back. Respect may take the form of ensuring that the patient is properly covered. Consider the husband who says of his wife after watching the nurse adjust the gown around the neckline and the covers in bed, 'My wife is a lady, she wouldn't have wanted her shoulder showing that way, Thank you for covering her back up.' During a research interview, a Muslim gentleman explains, 'To pray we need to have our knees covered, but here the gowns all stop short of the knees. How am I going to pray?'

Respect and dignity also involve recognizing the human as an individual. This has been done with 'All about Me' posters. Large flip chart sized post-its or printed sheets of oversized papers that affix to the wall can be used for families to describe the patient and family, attach pictures, and describe favorite pastimes. In this manner the person who is being cared for is honored not as 'sepsis in bed 13' but instead 'George Jones, grandfather of three whose loving wife quilts in her spare time while they vacation in their motor home around the country.' All about Me posters provide an invitation for staff and physicians to engage in the life of the patient and family to form a true caring relationship instead of providing surface tasks at the outer edge of a relationship. Authentic discussions with patients and families about their lives promote a caring connection. Discussions can easily begin with "Tell me about your Dad…."

Problem Solving

Families may be given opportunities to engage in problem solving through presence during rounds and during family care conferences. Use of technical jargon may preclude family engagement in problem solving. Despite training in communication, teams may lapse into technical discussions that are not understood by families. When this happens, the nurse's role is to translate the problem-solving process so that families can understand. With routine nurse advocacy in this regard teams will be more likely to develop family centered communication skills that meet the information needs of the families. This is best achieved during rounds or conferences. The reality is that physicians are often pressured for time during rounds. A less desired alternative is to explain how the decisions were made and why following rounds.

When the nurse is problem-solving changes in the patient's condition at the bedside, one strategy to keep families involved in problem solving is to talk through the problem solving out loud. For instance, "I see your Dad's urine output has dropped, and these measurements [pointing to the monitor] are a little lower than usual. I believe this suggests that he might be a little dehydrated. I am going to talk to the doctor to see if he agrees and discuss whether your Dad's treatment should change." Discussions like these build trust with the family and also help them to understand the purpose of all of the monitoring.

When present during rounds it has been documented that families often have information about baseline medical history that helps inform rounds and contributes to the differential diagnosis, altering the treatment plan (Jacobowski, Girard, Mulder, & Ely, 2010; Knoderer, 2009; Rotman-Pikielny et al., 2007). When this happens, it is important to thank the family for the information and comment to them that the information was helpful. Maintaining eye contact with the family during rounds and asking whether or not they have anything to add opens up the discussion. Many families will at first be intimidated, but when invited into the discussion will be more likely to contribute key information. The invitation to participate demonstrates respect, diminishes hierarchical structure and makes families feel as if they are a part of the team. This engagement may decrease stress and build trust.

Family presence on rounds may be more common in the United States than in other countries. For instance, in many ICUs in the United Kingdom, families are asked to leave during medical rounds because of the environment. The layout of many intensive care units makes it difficult for discussions about patients held at the bed space to be kept confidential from visitors at adjacent bed spaces. Therefore, families are prevented from contributing to discussions, and gaining information and building a sense of trust as suggested above., when the round is in progress. Units need to explore ways of maintaining a patient's confidentiality while including families in decision-making as part of the team. Strategies have been proposed to overcome this environmental barrier and include asking families of the person in the next bed to leave while the family of the patient being rounded on is present. A values analysis could also be conducted to see if privacy is a concern for the families involved. When asked, families often report that being allowed to be present is more important than someone overhearing information about their family member (J. E. Davidson, 2013).

The Role of Surrogate Decision-Maker

When patients cannot speak for themselves, families need to be taught the role of surrogate decision-maker. The patient surrogate is the person who is responsible for helping the physician make decisions in the patient's best interest given what is known about the patient's wishes. The surrogate needs to be instructed early and often regarding the standard of substituted judgment: that when asked opinions regarding decisions, the response should be framed within the context of "What would the patient have wanted?". Emphasizing the patient's own preferences accomplishes two goals: 1) maintaining respect for the patient as an individual with personal values and 2) relieving the family of the burden of making decisions based upon their own values.

Families have different levels of desired participation. It is recommended that each family is assessed for their own individual preference for participating in decision-making. It is further recommended that a shared decision-making model be implemented as a default, because it has been shown that most families prefer to be involved after being presented facts and options. However, the team needs to be flexible in approach if the family does not want to participate in decision-making, preferring a more paternalistic approach (Cox et al., 2012; J. E. Davidson et al., 2007), (Kon, in review, Shared decision making, Critical Care Medicine). One fear of clinicians when offering family involvement in decision-making is that families will request inappropriate treatment. It is the role of the physician to only offer medically appropriate treatments. If the family suggests inappropriate treatment, and the physician declines the request, it is the role of the nurse to support the families in understanding why the request was declined. Whenever a dispute about the treatment plan cannot be resolved by increased communication, explanation or family care conference, an ethics consult is indicated.

Each family will have their own method of determining who will participate in decision-making, or who will serve as surrogates for incapable patients, which may be culturally mediated. In some cultures the oldest son is the decision-maker. In others it is the oldest child. In still others it is a tribal elder or religious leader who is consulted for important decisions. Depending upon the country and region there may be guidelines for who should participate in decision-making. In the United States there is a standard consent lineage that physicians are free to modify when indicated by the best interests of the patient. The surrogate decision-maker is considered in this order: designated durable power of medical attorney, spouse, child, adult sibling. Others may be considered according to patient preference, culture, and best interest of the patient. For instance, if the patient does not have a durable power of medical attorney (DPOMA) designated or a spouse, but has been living with a domestic partner for several years, and this person knows the patient best, the physician may use this person to inform decision-making over a child or adult sibling who has been estranged from the patient or not connected to the patient. However, this can give rise to conflict, where functional and legal families disagree, and there have been a small number of such cases reported in healthcare journals,(Gonzales, Dever, & Singleton, 1999; Hyde, Kautz, & Jordan, 2013).

In parts of the UK, the Mental Capacity Act was introduced to address decision-making in relation to financial, healthcare, and other day-to-day issues ("Mental Capacity Act Code of Practice," 2013). It applies to all people 16 years and over, resident or present in England and Wales. Where a patient is deemed not to have the mental capacity to make decisions related to their own care, the Act requires healthcare workers to ensure that decisions made on behalf of an individual are always made in the best interests of that individual. The Act provides a checklist of factors that decision-makers must work through in deciding what is in a person's best interests. A patient's mental capacity should be tested using recognized tools. They cannot be deemed incapable just because they make decisions that others consider unwise. If an adult is not able to give valid consent, no person may give valid consent to treatment on behalf of an adult patient lacking capacity. Therefore, where an individual such as a carer (including a friend or relative), an attorney appointed under a Lasting Power of Attorney (LPA), or a deputy appointed by court, is approached with regard to treatment approval, this is recorded as 'assent', not 'consent', and healthcare organizations use separate documentation to acknowledge this difference. The Act also recognizes the consent given in advance by an individual in the form of an 'advance directive'. Where an LPA has been appointed by an individual to act as their proxy, this will have been lodged with the Office of the Public Guardian. The LPA does not authorize an attorney to refuse life-sustaining treatment unless there is express provision to this effect in the formal document (Johnston & Liddle, 2007).

Recently, researchers have been paying more attention to conflicts in ICU, including those that arise between the healthcare team and the family. In 2007, the European Society of Intensive Care Medicine's (ESICM) ethics committee felt the need to define conflicts in ICU, to aid with monitoring their sources and consequences (Fulbrook et al., 2007). Conflicts have a negative impact on patient safety, patient/family centered care, team welfare, and cohesion. Conflicts generate staff burnout and increase healthcare costs. Prevention strategies need to be developed, to include guidelines on how to improve the understanding of family experience, preferences and values, as well as evidence-based communication (Fassier & Azoulay, 2010).

Communication

Critical illness is an unfamiliar experience for most families. Everything that is done needs to be explained iteratively and repeatedly throughout the stay. Due to the crisis nature of critical illness, it cannot be expected that families will remember what was said earlier in the day or the day before. Most families have an unquenchable thirst for information. The more they understand about what is happening in the room, the more confidence they can have that everything is being done. Lack of communication or delayed information is one of the most frequently reported family dissatisfiers. Physicians are encouraged to update families daily and with significant changes in condition. When this is not happening, the nurse's role is to facilitate a discussion between the family and physician. Designating a spokesperson to communicate with the physician streamlines communication and decreases the time the physician will spend in communicating with families. However, the entire family will need information to minimize stress response to their exposure to critical illness. The nurse's role also includes teaching the spokesperson methods of keeping the family unit informed. This may include strategies like starting a family webpage or other social media.

Often nurses are uncomfortable with what information they can share with families. It is customarily accepted that the physicians should inform families of new diagnoses, comorbidities or likelihood of death. Once any of these items has been shared with the family it is acceptable for the nurse to explain the condition in terms the family understands or provide supporting educational materials about the condition or prognosis. Many items for families can be found free of charge at http://www.myicucare.org/Pages/default.aspx. The UK patient organization 'ICU Steps' has produced a guide for patients and relatives. It is available to download for free in 14 languages from www.icusteps.org along with other patient education tools. Nurse leaders should maintain a ready reference library of brochures, videos or written information that can supplement verbal discussion with family. It is known that pamphlets coupled with verbal communication and/or video are more effective at reducing stress than either method of education alone (Lautrette et al., 2007; Melnyk et al., 2004; Melnyk & Feinstein, 2009; Melnyk et al., 2006).

Family Care Conferences

Due to the complexity of critical illness there are often multiple providers involved in the care of each patient. Each provider contributes to the treatment plan. Family care conferences provide the opportunity to weave together all of the input from the variety of people on the team into one consolidated description of what is happening and what could happen next.

Family care conferences are advocated within the first 24 hours of admission to ICU, with important changes of condition, when death is first considered as a possible outcome, and at least every 7 days (J.E. Davidson et al., 2007).

There are many methods of care conferencing. All of them have these commonalities: Obtain information from consults prior to the conference to gain a full understanding of the current situation. Attempt to hold the conference at a time of the day that will encourage family presence, acknowledging the work responsibilities of some families. Invite key participants in the patient's care. Provide introductions so that each person in the room understands the role of each person present. Prepare a comfortable environment for the discussion. Allow families to vent their concerns, frustrations and questions first by asking probing questions. Families will not truly hear or absorb any new information until their communication needs in that regard are met. Come to understand the patient as a person through the eyes of the family. Gain an understanding for the values of the patient. Explain the surrogate role. Explain the current situation. Explain the choices for appropriate next steps. Collaborate with the family to formulate goals and plans. Thank the family for their time and valuable contributions to the discussion. Record the major points in the medical record and provide updates during hand-off between providers and shifts (Baile et al., 2000; Curtis & White, 2008; Lautrette et al., 2007; Shaw, Davidson, Smilde, Sondoozi, & Agan, 2013).

The nurse's role in this process varies from organization to organization and may include: stimulating the conference after identifying the need, coordinating the conference, documenting conference outcomes, clarifying physician input to family in lay terms, facilitating discussion so that family members have a voice, gathering input from consultants who cannot attend the conference to present to the family and/or providing a summary of the progress of the patient to date. The nurse clarifies role expectations prior to the start of the conference.

Affiliation Needs

It is a basic human need to need each other. Isolation is not a normal existence. A sense of belonging is essential. This factor of affiliation takes into account the family member's need to be engaged in the critical care experience and included in decision-making. Facilitating family presence at rounds, resuscitation and procedures (when desired), and promoting flexible open visiting are all ways that we help families to meet their affiliation needs during critical illness. Without presence it is difficult for them to have the knowledge to engage in surrogate decision-making.

Visiting

Visiting should be open and flexible to meet the needs of the family (Davidson 2007). Traditionally visiting hours have been set to meet the needs of staff and physicians. There are several issues with posting rigid visiting times: the times may not meet family needs, the family may feel obligated to stay despite restrictions and the cultural or religious obligations of the family require presence despite limitations imposed by the healthcare provider.

Family obligations may preclude family members from being present when it is convenient for staff. One common example is the family member who works 8 hour days, then travels an hour to the hospital. This would invariably result in a visit landing on or just before a change of shift. If the staff is rigid with rules and times, the family member would be asked to leave for the peri-shift routine which could last two hours. By then exhausted, they would be allowed to come back in before going home to bed. Often family members are asked to go home at night to rest. When researching this topic in the literature, no evidence was found to support sending home family members at night. During the period of critical illness where family members feel the need to safeguard, sending them home may actually cause harm. One biographical case study confirms possible harm by sending families home when they feel the need to stay (Judy. E Davidson, Harvey, Schuller, & Black, 2013). In this case the patient was a young adult trauma victim. Physicians rounding throughout the day had alerted the mother that the patient may die at any time. She was not expected to survive. At night the mother couldn't bear the thought of her daughter lying alone helpless in the bed and possibly dying without her there. The staff, however, enforced a no nighttime visitation policy and told her that they would call her in with changes. The mother rented a motor home so that she could sleep in the parking lot closer to her daughter. One night she even hid under the bed because she couldn’t bring herself to leave. During the night the daughter asked for her mother’s presence because she feared death. The nurses told her that they had called her, but she never came. The patient, though sedated and critically ill, realized that the nurse had not been truthful and her mother was never called. She miraculously recovered from the event, but five years later the mother and daughter were both receiving psychotherapy to overcome the post-traumatic stress: stress that they describe was caused not by the critical illness, and not by the trauma, but instead by the forced separation during this near-death event.

There is no evidence to support the notion that family presence increases infection. To the converse, there is evidence to support that healthcare workers transmit infection. There is no evidence to support the notion that families increase stress or cause patient harm. There is partial truth to the statement that families may cause staff stress(J. E. Davidson et al., 2014). For this reason, it is important to include methods of dealing with family members and how respond to family needs as a part of critical care training.

In 2011, the British Association of Critical Care Nurses (BACCN) commissioned a Position Statement on Visiting policies for UK Adult Intensive Care Units as it had received so many requests for guidance on best practice(Gibson et al., 2012). It set out a list of standards that should be expected by both patients and relatives:

Patients Should Expect:

- To have their privacy, dignity and cultural beliefs recognized
- Confidentiality
- The choice of whether or not to have visitors
- The choice to decide who they want to visit including children and other loved ones
- The choice of care assisted by their relatives
- A critical care team who recognize the importance and value of visiting

Relatives Should Have:

- A comfortable and accessible waiting room with bathroom facilities nearby
- Access to overnight accommodation in the vicinity of the ICU
- Easy access to food and drink
- A telephone nearby
- Access to relevant information regarding critical illness, the critical care environment and aftercare and support. This should be reinforced with written materials
- A separate area for private discussions with healthcare professionals
- Involvement in patient care as the patient would wish
- Written information regarding the unit procedures e.g. hand washing, times of ward rounds
- Information concerning patient progress on at least a daily basis
- Information when there are any significant changes to the patient's condition
- Not have to wait for long periods of time in the waiting room without regular updates
- Access to interpretation facilities if needed

A particular issue for critical care units in Europe related to the provision of facilities for visitors, as most patients are not nursed in single rooms. Relatives can spend a significant part of any visit in a waiting area, away from the patient's bedside. These waiting areas can be some distance from the clinical area, and require the negotiation of a number of barriers to gain access to their loved one. When constructing new ICUs it is now recommended as best practice to provide dedicated family space at each bed space (Rashid, 2006, 2014). Waiting areas can be improved through attention to décor, seating, and the provision of a receptionist or volunteer that could act as an intermediary in facilitating communication between ICU staff and patient families(Deitrick et al., 2005). One waiting room was described as ‘a place to go, not a place to stay’(Kutash & Northrop, 2007).

Pet visitation remains controversial, yet there is no evidence that pet visitation can cause harm (J.E. Davidson et al., 2007). There is some evidence that pet visitation improves recovery. In some situations the relationship that humans have with their pets is just as strong as those that they have with other humans. Receiving unconditional love from a pet during difficult times has been known to help heal (Cole, Gawlinski, Steers, & Kotlerman, 2007).

Rounds /Resuscitation and Procedures

There is ample evidence to support that family presence on rounds supports family communication without significantly lengthening rounds, detracting from teaching or causing harm to families (Cypress, 2012; J. E. Davidson, 2013). Families often provide new knowledge to the team to help refine the treatment plan and prevent unnecessary testing. It has been found that between 85 and 100% of families, when asked, want to be present on rounds and value the opportunity for obtaining information during rounds (J. E. Davidson, 2013).

Admittedly, there is controversy amongst clinicians regarding the benefit vs. risk of including families in rounds. Most opposition comes from clinicians who have not experienced family presence on rounds and worry about time, teaching or risk of litigation. However, when tested, the benefit outweighs the burden and may include greater faith that the clinicians attempted everything possible, earlier recognition that efforts should be stopped, and greater trust in the healthcare team. Although the fear of litigation has clearly been reported, it has not been substantiated. Clinicians universally agree that if families are provided the opportunity to be present during resuscitation that a family liaison is needed on the resuscitation team to attend to their needs. (J. E. Davidson, 2013) Staff and physicians also need training on how to deal with family presence at these events and debriefings to process the exposure to raw grief when patients do not survive (J. E. Davidson, Buenavista, Hobbs, & Kracht, 2011; J. E. Davidson et al., 2007).

On a similar note, it has been recommended that families be allowed presence at procedures, including brain death evaluation (Davidson 2007, Tawill, 2014). If the family expresses a wish to be present, it may help the family process what is happening while calming the patient.

Because research has shown that family presence at resuscitation may improve family outcomes and does not cause harm, family presence at resuscitation is endorsed by the American Association of Critical Care Nurses and Society of Critical Care Medicine (J.E. Davidson et al., 2007; "Family presence during invasive procedures and resuscitation in the emergency department," 2010).

In 2007, the European Federation of Critical Care Nurses (EfCCNa) coordinated the development of a position statement also endorsing the presence of family members during cardiopulmonary resuscitation (Fulbrook et al, 2007). The following statements were made:

- All patients have the right to have family members present during resuscitation (where this is in the best interests of the patient)
- The patient’s family members should be offered the opportunity to be present during resuscitation of a relative
- Support should be provided by an appropriately qualified health care professional whose responsibility is to care for family members witnessing cardiopulmonary resuscitation
- Professional counseling should be offered to family members who have witnessed a resuscitation event
- All members of the resuscitation team who were involved in a resuscitation attempt when family members were present should participate in team debriefing
- All intensive and critical care units should have multi-disciplinary written guidelines on the presence of family members during cardiopulmonary resuscitation

A systematic review of the evidence supports the practice of family presence despite staff and physician reluctance to adopt the practice (Salmond, Paplanus, & Avadhani, 2014). There is worldwide debate by staff and physicians regarding family presence at resuscitation and geographic variation in acceptance and adoption of this practice (Leventakou, 2011; Salmond et al., 2014). Presence at resuscitation appears to be a component of FCC that may be mediated by cultural values. For instance, perspectives of staff and physicians in Turkey (Badir & Sepit, 2007; Demir, 2008; Gunes & Zaybak, 2009), Greece (Vavarouta, Xanthos, Papadimitriou, Kouskouni, & Iacovidou, 2011) and Israel (Ganz & Yoffe, 2012), demonstrate a consistently negative response to the idea of FP at resuscitation by nurses and physicians. Despite positive benefit noted in experimental trials and published reports of family desire to be present, policies are either not present or not endorsed. Obstacles to staff and physician adherence to policies related to family presence at resuscitation include the fact that clinicians do not feel prepared or do not want to be watched during these stressful events (J. E. Davidson, 2006; J. E. Davidson et al., 2011). Most opposition comes from staff or physicians who have not experienced FP at resuscitation (J. E. Davidson, 2006). Because the positive benefit of family presence has been documented, organizations are encouraged to proactively work on reducing the barriers to presence by preparing clinicians to work during crisis in the presence of family. Most, but not all families want to be present (Salmond et al., 2014). Because of cultural and personal variation in the desire to be present, the resuscitation team should take family's beliefs, values and rituals into account and offer, but not mandate family presence.

Summary of the Quality Caring Model

In summary, each of the eight factors influencing quality caring has been reviewed with commentary as to how they could be applied to practice in the critical care environment. It is obvious that the focus of the Quality Caring Model is to develop relationships that will enhance a healthy work environment that will be conducive to providing authentic caring and healing. Next, Facilitated Sensemaking, developed and tested for feasibility by this author (J. E. Davidson, 2010; J. E. Davidson et al., 2010a), will be explored as an adjunctive prescriptive strategy to further address the needs of family members of critically ill patients. The two models are complementary and at some times overlap, but do not conflict or compete with each other.

Facilitated Sensemaking

The Facilitated Sensemaking mid-range theory of nursing is presented as a way to engage the family in care. This theory specific to ICU nursing complements Joanne Duffy's Quality Nursing Caring model while being prescriptive regarding nursing interventions. The model has been tested for feasibility and well-received by families. When tested, these activities added approximately 17 minutes of care per day. The amount of time it took to care for the family in this manner increased when previous needs were unmet (J. E. Davidson, 2010; J. E. Davidson et al., 2010a) . The assumptions and propositional statements are presented in Table 10-1.

Table 10-1: Facilitated Sensemaking Assumptions and Propositions

Assumptions:

- Critical illness is a family crisis.
- Families desire proximity and information.
- Each family is unique and may require different approaches to family centered care.

Propositions:

- Families need and benefit from a purpose in crisis.
- Families need our support to interpret what is happening during an ICU stay.
- Families require care from ICU staff and caring for families is within the realm of ICU nursing.
- How we deal with families of ICU patients may have a long-term impact on both patients and families.

- Minimizing fear, horror and helplessness through structured ICU care of families may decrease PICS-F.
- Supporting families during critical illness may have a positive downstream effect on patients in terms of:
    - Treatment adherence
    - Mobility and Physical Function
    - Cognitive function
    - Attaining treatment goals

Figure 10-2: Facilitated Sensemaking

Families experience a crisis when exposed to critical illness. They need to understand what has happened, and then reframe their lives to understand what their new role is as family member of an ICU patient. Sensemaking includes discrete structured activities that a nurse deploys to support families in understanding what has happened and how to adjust to their new role. These sensemaking activities can be clustered into four themes: developing caring relationships, communication, presence and decision-making. It is theorized that if the nurse tends to these sensemaking activities that family outcomes will improve. Families are experiencing an acute crisis. We are there in the moment of their crisis. They are being exposed to a life threatening situation that may cause feelings of fear, horror or helplessness. These are the antecedents to post-traumatic stress syndrome. If we take action to decrease fear though making sense of the situation and environment, allow them to engage in meaningful activities to prevent helplessness and put the situation in context to decrease horror, it is possible that we could modulate the limbic system response to stress and minimize the stress response and resultant outcomes. The healthier, better adjusted family member will be in a better position to provide caregiving and support to the patient which should in turn improve patient outcomes.

Developing Caring Relationships

Developing caring relationships is important to establish the trust needed to allow families to cope. In qualitative studies on clinician/family dynamics families report that the relationship between the nurse and family can either help them cope or cause stress. According to the biomedical ethical principle of nonmaleficence, to do no harm, we are duty-bound to authentically care for families in a way that does not stimulate stress. Families also report that stress is increased when the relationship is strained by perceived power-based relationships. When the clinicians tell families what they can and cannot do instead of treating them as equal partners in care it causes stress (Fenwick et al., 2000). Respect is shown when the nurse authentically demonstrates interest about the life of the patient and family, their values and goals. It is not enough for families to be allowed to be present, but instead welcoming their input and active participation is encouraged. Create an atmosphere open to hearing their fears and concerns. Allow them to speak about the risk of death or permanent impairment. Ask a question such as, “Is there anything I can do for you today that would make this any easier given what you are going through?” This simple question has been shown to reveal specific family needs otherwise unknown to the healthcare team (J. E. Davidson, Daly, Agan, Brady, & Higgins, 2010b).

Family presence should be encouraged in the environment. It is known that nurses do not adhere to visiting policies or standards even if they exist. Families report that the inconsistency between providers causes undue stress. Families of infants report wondering, ‘Whose baby is this anyway?’ ‘Why do I have to ask to be allowed to be present?’ Think about the nurse’s station and how in many hospitals this is ‘off limits’ to families. The clear demarcation between ‘our space and their space’ creates tension and detracts from the family centered approach. Presence at rounds and resuscitation has already been discussed. In order to avoid doing harm to families, we need to be consistent about our approach to family presence. Presence should be dictated by the needs and values of the families.

New ICU nurses may be challenged with learning how to care in front of families and dealing with their own stress of being watched in the workplace. These simple techniques may help adjust to family presence. First read all of the patient education materials in your department specific to the types of patients who are commonly admitted. Also read the patient/family education brochures at http://www.myicucare.org/Pages/default.aspx . Reading patient education materials provides nurses with useful phrases and descriptions of common ICU occurrences to be better informed to speak to families in a way that they understand. Often new nurses report that they are uncomfortable being watched while working and describe it as if they are an actor on stage. The feeling of being watched causes discomfort especially when developing new skills. An approach to get past these feelings is to talk through your actions in a calm voice aloud converting the situation from ‘actor’ to ‘teacher’. “I am now measuring how much urine came out over the last hour. I always hope it is more than 30 milliliters and yes, it is. We’re doing fine here. Now I’m taking down all the numbers from the monitor. The most important one to me is the blue one. That measures the amount of oxygen in the blood. As long as that one stays about 90 we are O.K." Keep the sentences calm and confident as your preceptor might have done when teaching you. Even if things start going badly, the fact that you’ve picked up on it and are doing something about it can be reassuring to the family.

Communication Sensemaking Activities

Truth-telling

Families have an insatiable thirst for information, though limited capacity to process it during crisis. For this reason it is always better to over-communicate and not assume that they should already understand what is going on. Family members will fill in any blank in their knowledge with distortions and myths that can be harmful to the psyche. It is generally accepted that for most people the factual truth is less painful to endure than not knowing what is happening. However, nurses need to be prepared for cultural variations regarding the need to be informed of negative prognoses.

Western healthcare systems hold disclosing factual information to patients and/or their families as a basic moral rule. This relates to the ethical principle of autonomy, where withholding information would be considered to be denying autonomy to a patient and/or their family. In addition, healthcare staff can feel obliged to tell the truth because of legislation and professional codes of ethics. In the West, autonomy has been called the 'first amongst equals' in relation to the other principles of nonmaleficence, beneficence and justice. However, in other cultures such as in Japan, or Iran, nonmaleficence (do no harm) is seen as superior, and should be considered in relation to information giving, in particular where this relates to the concept of hope. Taking away hope is seen as harmful to the patient, and/or their family; withholding the truth is seen as an admirable act.

Various studies have suggested that in countries where non-disclosure is the norm, a high majority of people want to be informed. Yet, in other countries where truth telling is the norm there are patients who are reluctant to be informed (Shahidi, 2010). Some patients or their family may appear to be avoiding information, because they only make indirect requests. If healthcare workers do not recognize this, it can lead to information seekers experiencing frustration and uncertainty about their illness and outcomes. Older, less educated patients may appear to be avoiding gaining information because of the use of passive communication styles. Where interpreters have been used to convey information, the information communicated may be altered, or the interpreter may refuse to translate certain facts, as the interpreter conforms to cultural norms. Alternatively, where interpreters have conveyed information accurately, this may result in negative evaluations of healthcare services by the patient on the receiving end (Brashers, Goldsmith, & Hsieh, 2002).

The important message to take away from this is that it is crucial that healthcare workers avoid premature assumptions based on their own values regarding information giving. Clinicians need to avoid the conviction that one's own way is the best or the only right way (Pergert & Lutzen, 2011). The first action is to spend time understanding the patient's preference for information and act in the patient's best interests. (Brashers et al., 2002; Pergert & Lutzen, 2011; Shahidi, 2010). The ACCM/SCCM has recognized the right to refusal of information and endorses honoring patient wishes to defer information (J.E. Davidson et al., 2007).

De-Coding the Environment

The nurse de-codes the environment by explaining the purpose of the machines, alarms, readings, lines and tubes. This may need to be done repeatedly and frequently for the family to absorb during crisis. It is also helpful to give them some guidance about the alarms. Explain how they have a different tone and sound.

> “Some of them are not critical, like when the alarm that tells you your clothes are dry in the dryer. If you don’t get the clothes right away it is O.K. Other alarms are like the one on the oven telling you the cake is done. That alarm is more important but still, the cake will be OK if you wait a few minutes to attend to it. Other alarms need immediate attention, like the smoke alarm in your house. Nurses know all the alarms and which ones need attention right away. If no one is in the room, the alarms are also displayed at the desk, so there is always someone else that can help."

In addition to talking through your actions, nurses provide interpretation of communication provided to the family by others. Attend every discussion that the physicians have with family members. This is challenging, but it is reasonable to ask the charge nurse to watch your patients so that you can be with the physician during informational meetings. After the physician leaves the nurse is better prepared to answer family questions, redirect false understandings, and identify when family members may have received mixed messages from multiple providers.

Apply principles of reflective learning to family communication. Before the end of every visit ask questions like, “What was the most important thing that happened with your husband today?” and “What will you tell the rest of your family about what happened today?" Ask instead of tell to see if the facts have been embedded properly. Sort them out and untangle any myths before the family member leaves so that they don’t become permanent distortions in the perception of what has happened.

A diary has been shown to improve family and patient outcomes (Garrouste-Orgeas et al., 2012; Griffiths & Jones, 2009; Jones et al., 2010; Jones, Backman, & Griffiths, 2012).

Generally these diaries are maintained by staff and physicians, writing notes of encouragement and daily progress. Pictures of the equipment and an explanation about them can be included. A debriefing session is advocated before giving the diary to the family member at the end of stay or at a discharge follow up visit. Then family members can help patients reconstruct their ICU stay using the diary when they are ready to hear about it. Filling in the gaps in the memory can be an important step towards recovery following discharge. For bereaved spouses, the diary may serve as a reminder of the caring relationships they had developed with staff and physicians which may bring them comfort in their grief. Instructions for how to set up a diary program for your ICU can be found at www.icudiary.org.

Participation in Care

Family participation in care should be offered as a standard element of FCC. Family members vary in their desire to participate at the bedside. Family preference for caregiving may be assessed using standardized tools such as the Family Preference Index that can be found at consultgerirn.org/uploads/File/trythis/try_this_22.pdf. (Boltz, 2012) For many, engaging in the care helps to decrease the sensation of helplessness that is a precursor to anxiety and stress disorders. Having a purpose during crisis helps humans to navigate crisis. We define ourselves by the actions we take during crisis. To adjust to the new role of 'family member of a critically ill patient' the family needs to learn what actions they can take to support the healing or dying process. This will need to be encouraged and taught by the nurse. Understanding how to participate in care decreases the fear and horror of the unknown. Participation may be as simple as applying lip balm, or as complex as helping with personal hygiene or bathing.

Because over 50% of ICU patients require caregiving after being discharged to home, the more the family learns about caregiving in the hospital, the better they will be prepared for caregiving at home (Desai et al., 2011; "Family Caregiving," 2011). When the Facilitated Sensemaking model was tested a kit was given to family members with these items:

- Nail file and fragrance free lotion
- Dominoes

- Word Searches
- Playing cards
- Lip Balm
- Blank Journal
- Non-denominational prayer and common list of family needs
- Standard lead pencil (not mechanical) with occupational therapy foam grip attached

All families reported that the items were helpful and recommended keeping all items in the kit. The list of family needs could be reviewed together as an assessment tool to see if the family had any unmet needs. This was often helpful and produced a different answer than when asked, 'Do you need anything?' For instance, one family reviewed the list and said that yes, they could use a visit from the chaplain and didn't know one was available. The rest of the contents in the kit could be used in a modified manner based upon the level of illness/injury of the patient. Cards or dominoes could be set out on the bedside table and the patient could be asked to point to the one with the most points. Or 'point to the 2'. With word searches, enlarged in a very large font, the patient could be asked to point to the letters of his name or point to the J. These activities were referred to as 'brain strengthening activities' which gave the family the connotation that they were helping with something of importance (J. E. Davidson et al., 2010a).

For those patients not yet able to bear weight or get out of bed, families were taught passive flexion of the ankle to prevent blood clots. The instruction was to flex the ankle and hold for 10 seconds, repeat 10 times on each foot. It was described that the flexion mimicked the activity of putting pressure on the bottom of the foot while walking. Preventing blood clots from immobility also conveyed to the family that they were being trusted with an important aspect of care. It is true that this is not necessary if the patient is on anticoagulants and pulsatile venous compression, but it is not false that it does add support to the regime of deep vein thrombosis prevention. Passive range of motion activities were also taught. Families were encouraged to rotate, flex and extend every joint (not affected by trauma) 10 times every hour (J. E. Davidson et al., 2010a).

If the patient was not conscious or able to participate, the family was told they could use the items in the kit to busy themselves while visiting. It was not possible to predict which items different family members would use. For instance, a man was found to giving his brother a pedicure, something that one might think of as a 'female' activity. The most commonly used item in the kit was the lip balm, which families used instinctively without interfering with the endotracheal tube.

Families were encouraged to speak in conversation to the patient as if they were awake, even if not conscious or able to respond. They were taught how to use the pencil with occupational therapy grip foam attached to communicate with awake intubated patients. Families were also encouraged to play music that the patient liked or read the newspaper or novels while visiting to engage the brain. Explaining that keeping the brain active and engaged helps to keep the brain strong emphasized why the participation could be helpful. The point of all of these activities is that even in the worst of outcomes, if the family had important activities to engage in, they could look back and confirm to themselves that they had done everything possible to help their family member prior to death (J. E. Davidson et al., 2010a).

Whereas nurses of children and adult patients help to maintain family integrity, by providing activities that the families can do while visiting, families of babies need help to become a family. Participation in care is an important aspect of bonding as parents, grandparents and siblings. All activities between family members and critically ill infants need to be encouraged and taught to include skin-to-skin care, feeding, reading and conversation to promote brain stimulation and provision of touch. These activities are standard components of developmental care to prevent long-term developmental delay (Caskey, Stephens, Tucker, & Vohr, 2014; Westrup, 2014).

Nurses Improving Care for Healthsystem Elders (NICHE) is a program built to support healthcare organizations in optimizing care of older adults. Their website includes a free open source section for caregiving information which can be found at http://www.nicheprogram.org/patient_and_family_resources.

Participation in Decision-Making

As stated above in the section on Problem Solving, families have an opportunity to participate in decision-making during daily rounds, family care conferences and while visiting. According to the Facilitated Sensemaking theory, it is the nurse's responsibility to keep the family informed well enough to participate in the decision-making process and encourage the family to provide input during discussions about the treatment plan. By listening to the decision-making activities of all members of the healthcare team, the family learns to make sense of the situation which decreases fear and horror of the unknown, known precursors to stress disorders.

When the family provides useful information, it is important to thank them for the information to call attention to the fact that their input has been helpful. Family members of patients with chronic pain often have useful insight into the non-verbal expressions of pain that the patient exhibits at home. Inquiring about these is one easy place to start a dialogue of respect and involvement in the treatment plan. Inviting the family to alert the nurse when the patient exhibits these non-verbal cues of pain also invites involvement and further helps the family to define their role in the ICU.

Leadership Responsibilities: Creating a Family Centered Care Sustainability Plan

Setting up a sustainability plan to promote FCC is a leadership responsibility generally shared between nursing and medicine. The program of FCC will be more successful if quality monitoring is set up to ensure that policies, procedures or guidelines related to FCC are adopted into practice. A quality monitoring program conveys to staff and physicians that the principles of FCC are not optional and are instead essential elements of care.

The first step is to come to consensus on the essential elements of this organization's FCC. Which aspects of FCC will become practice standards? What is the current state vs. future state of FCC? Once consensus is achieved on this, transform what was once a visiting policy into a FCC policy. Create interdisciplinary practice standards that will be monitored and adhered to. To start, conduct a gap analysis to evaluate what is currently done in your environment vs. missing. Read the latest FCC practice guideline published on www.guideline.gov. Discuss whether any of the recommendations should be adopted into practice at an interprofessional critical care committee.

Once minimal standards have been set, and communicated to the team, performance improvement monitoring should include both process measures of success and outcome measures of success. Process measures will include whether or not the targeted services are in place (e.g., family presence on rounds) and staff and physicians are adhering to these practices. For instance, if an ICU chooses to include family presence and engagement on rounds, a weekly spot check of the number of families present on rounds could be tallied on one shift to measure compliance with the protocol. Another method of gathering this data is to walk through the ICU one day a week and ask families if they were invited to rounds. If the ICU had already included family presence on rounds, but now wants to advance to family engagement in rounds (actively included : encouraged to participate by informing the team of patient baseline, history or asking questions), this could also be counted on one day's rounds per week to calculate protocol compliance. The number of families during one day's rounds that are invited to speak during the rounding process can be calculated as a percent.

Outcome measures include measuring whether the program of FCC results in family satisfaction with ICU services. Routine patient satisfaction surveys rarely adequately assess patient and family satisfaction with services performed in the critical care environment. One commonly used validated tool that can be used instead for this purpose is the FS-ICU (FS =family satisfaction) developed by the Society of Critical Care Medicine and may be found open-source at http://www.thecarenet.ca/docs/fss/FS_ICU_34.pdf. The survey includes two subscales: family satisfaction with care and family satisfaction with communication. Revision to add questions related to timeliness of information, appropriateness of communication and comportment (professional vs. rude communication have been proposed based upon research findings) (Judy E. Davidson, 2013a, 2013b; Shaw et al., 2013). This tool may be used to conduct a baseline assessment prior to taking action to improve FCC, and then tailor action items based upon the results.

Action plans are based upon recommendations to provide family with structured communication, presence, tactics for engagement at the bedside, and support to help families bond (in the NICU) or maintain family integrity (in pediatrics and adults).

There now follows a case study that illustrates how using the strategies discussed for a program of FCC can assist families to come to terms with critical illness quickly and effectively. This enables the family to live through, and make sense of the crisis in a way that avoids the development of PICS-Family.

Case Study: Putting it All Together: Making Sense of Critical Illness: One Family's Experience

The benefits of FCC are clear to my own family in view of our experience with our first child, born several years ago with a severe congenital heart defect. Throughout the crisis of his birth, sudden illness, rescue, treatment, and eventual recovery, we faced emergencies and uncertainties we'd never dreamed of. We confronted options and decisions we never wanted to think about, much less live through. Our situation demanded immediate response, ongoing accommodations, and radical readjustment of hopes, and expectations. Our baby was born fighting for his life. We found ourselves fighting along with him, and for him, in the terrible and wonderful NICU, with doctors and nurses and technicians, our new friends and allies. In the end, after two years of treatment, three open-heart surgeries, multiple visits to the catheterization laboratory, and some difficult complications, he won. We won. They saved him, and as they did so, they brought us along, my wife and me, in such a way that we could somehow manage and keep ourselves together as a family, ready to care for a sick little baby and able to care for ourselves.

In this section, I'll share some of our experience as a family making sense of our son's critical illness. I'll highlight typical family needs and professional interventions that drive effective family centered critical care. These needs are many: Family members need humane interpersonal support as they react to the emotional and psychological impact of the crisis. They need continual communication from the care team, and they need to see that team members communicate effectively with each other. They need medical education as they struggle to understand and gain insight into their loved one's condition, and what it means for the future. They need orientation to the often new and intimidating environment of the ICU, with its monitors, machinery, and bustle of nurses and doctors. They need guidance to understand their role as surrogate decision-makers, where this applies, and explanation of relevant bioethical concepts and principles of substituted judgment and best interest of the patient. They need practice, coaching and technical training, mostly from nurses, to prepare them for home caregiving. They need personalized, culturally competent emotional and spiritual care as they manage their own fears, uncertainties, and grief in the face of illness and mortality. Fundamentally, they need to feel *trust*: that they can trust the professional team to provide excellent care for their loved one, come what may. They need continuing assurance of the team's professionalism and interprofessionalism, working together for the good of their patient. And they need to feel included and cared for themselves--which they are brought into the "inside" of their loved one's care and they have a welcome role to play in it. When these needs are addressed, families fare better through the immediate crisis of illness and treatment, and are better prepared for phases to come, whether these include at-home caregiving, bereavement, or both. Family centered care minimizes harms to the family and thereby fosters conditions more favorable to the patient's best recovery, during and after intensive care.

Making Sense of Critical Illness: Communication in Crisis

Critical illness can be expected and inevitable, or sudden and traumatic. Either way, it forces families to contend with novel questions. As they put the pieces together and try to make sense of things, they need continuing communication and support from various members of the care team, and nurses in particular. In early stages of intensive care, families need basic medical information in order to come to terms (quite literally) with their patient's condition, often in the context of their participation in shared decision-making processes. They need personalized, culturally competent emotional, psychological, and spiritual care, as they contend with the impact of the crisis on themselves. Families are desperate for information and reassurance, and utterly reliant on relationships with care providers, as sources of information and support. Effective communication and relationship building are fundamental to effective FCC.

In my family's own case, our son's illness was wholly unexpected and emotionally devastating. Minutes after he was born, he went into apparent respiratory distress, and his rescue began. He was hustled quickly from the delivery room for treatment. Starting there, in those first few minutes, our own need for information, counsel, and human support was absolute. I'm grateful to say that our doctors and nurses met this need, to the best of their ability. We were updated as the indications became clear and even as they grew more dire. Postpartum "fluid in the lungs" became "pneumonia." Pneumonia gave way to a "heart murmur." Suctioning of the airway led to placement of an oxygen hood, soon followed by a mechanical ventilator. As we waited, moment by moment, finding by finding, we were at least kept in touch with things, alarming as they were. Our son (I'll call him John) was born with an undetected case of hypoplastic left heart syndrome (HLHS), a cluster of problems that includes, typically, an underdeveloped and too-small left ventricle, a dysfunctionally narrow aorta, an atrial septal defect (patent foramen ovale), leaky or narrow mitral and aortic valves, and (in our baby's case) a leaky tricuspid valve.

Presentation of John's illness could not have been more dramatic. He was born full term, nine pounds, rosy and pink. For his first few minutes, as his mom held him, and we cut the umbilicus and cleaned him up, he was fine, thanks to a small but critical thing: The ductus arteriosus stayed open. The patent ductus, normal to fetal anatomy, provides a passage between the aorta and the pulmonary artery, shunting circulation away from the fetal lungs.

Typically, it closes soon after birth---minutes or days. In John's case, however, the ductus, located just below the disastrous pathological narrowing of his aorta, was the only open route for any arterial circulation whatsoever. A dozen minutes after he was born, the ductus closed. I imagine it, surely inaccurately, as a doorway snapping shut---as it normally should---but in this case it shut down that only open route, backing up the entire system: decompensation, respiratory distress, desaturation, cyanosis, and all that follows. As soon as he was born, and his heart switched over to its normal course, he was in trouble. He stopped crying, started up with a little coughing sound, and before we knew it, the nurse had him out the door, the first one that day to save his life, after the OB brought him forth. Not a word was spoken, but the look in her eyes said it all.

Over the next two hours, we watched that door and clung to every word from each succeeding visit from doctor or nurse. John was rescued, stabilized, diagnosed with a heart murmur, and eventually transported to a children's hospital with a level three neonatal intensive care unit (NICU). "Would you like to hold the baby before he goes?" "Yes, we would," and we did, IV's, endotracheal tube, and all. There, downtown, HLHS was confirmed in the ghostly flicker of echocardiogram. A friend drove me there to meet with the doctors, on my own, my wife left behind, in pain, exhausted and horrified in the care of nurses and friends. The doctors advised a plan: John's condition, on the spectrum of HLHS, was not so severe--he had just enough left ventricle to work with. And the leaky valves could be sealed and the aorta ballooned up and stented, all in the catheterization laboratory, for circulation to begin. No need for open-heart procedures, a bit of grace. Treatment will proceed the next day, if you agree. I called my wife, and yes, we said yes.

Within hours, the doctors revised their assessment: John's condition was too severe, so the cardiac catheter treatments wouldn't do. Instead, a stronger response was advised: the Norwood procedure, a staged reconstruction of the system over three open-heart surgeries: one the next day, if we agreed a second in five or six months, and the third at 18 to 24 months of age. We were to go to the hospital the next morning, to talk to the doctors and decide how to proceed, whether to proceed, and what was best for the baby.

My wife was in labor for 21 hours, pushing for nearly three, before John was born. She held him at birth, those few minutes, and in minutes he was gone, off to the NICU. All we knew was what they told us. That morning, that day, we had only minutes or seconds to process things as they happened, and make some quick decisions about transport and treatment. We relied absolutely on John's care team for information, advice, and reassurance, and our need to make sense of things was an emergency in its own right. No one is prepared for such a thing, and we had no time at all to wrap our heads around it, but circumstances demanded our comprehension and decision-making.

Here is how the teams at both hospitals took care of us that first impossible day: They kept us informed, each step of the way, as much as possible. They acknowledged our own suffering and let us know they cared---that we counted, too. They showed that they understood, how much we needed information, and they promised to share what they found, as soon as they found it. Doctors and nurses provided information, explanations, and emotional support, all at once, in direct words and sympathetic gestures. Chaplains and social workers stopped in to check on other needs and offer spiritual care, additional support, and further resources (a breast pump and access to a medical library were high on our list). What helped us most, in those first hours, was not being left out, and knowing that we would hear from people, to help us bare with things.

Making Sense of Critical Illness: Building Trust in the Care Team

Two days old, John went through a six-hour surgery, Norwood stage one, and did well. He recovered steadily, but spent nearly three weeks in the NICU. We couldn't have coped without the information and support we received from the doctors, nurses, and other hospital staff. Our fears and anxieties were balanced against our growing sense of trust in the care team: Our baby was in bad shape, but he was in good hands. In the NICU, frightful as it was, we took confidence from the professionalism and commitment of John's providers; doctors, nurses, and technicians alike. I could relax, just a bit, and reconcile myself to my own uselessness and helplessness in this situation, knowing that very useful people were providing very expert help. It's out of my hands, but it’s okay. Better hands were at work.

John's providers inspired confidence and trust in various ways. They helped to take the mystery out of things---not just John's condition, but the ICU as a whole. From our first visit to the NICU, we were made to feel welcome. We were told straight up that our presence and engagement in John's care were important to his success. We received a thorough orientation---a tour of the facilities and explanation of protocols, for hand-washing, visitation, entrance to the unit, and so forth---giving the impression that our presence and participation there were taken for granted, totally the norm. At bedside, a superb nurse explained the various tubes, wires, machines, monitors, alarms, and routines. She explained her own work as she drew medications, cleaned lines, monitored fluids, and so on. She fielded our 10,001 questions, and she kept it light. We managed a laugh now and again. Talking us through it all, she conveyed the indirect message of her own professionalism, expertise, and technical control, in the midst of ongoing crisis. This, it struck me, is her "every day." She is comfortable here---it's *possible* to be comfortable here---and I drew comfort from this.

We were encouraged, leaned-upon even, to make ourselves known to the baby---to touch him, talk to him, sing to him---so that, despite the crisis and tubes and machinery, we could begin the serious business of loving our child. They made it possible for us to hold him, before and as soon as possible after his surgery, and invited us to feed him, bathe him, and change his little diapers, as he recovered and progressed. We were made to know by the nurses that this was our child, ours to love and protect, and no one else could take our place, particularly in this time. And my early sense of uselessness and helplessness began to fade. I learned how to be a father in such a place. Our nurses knew the importance of our presence there before we did, and helped us see it, too.

Our nurses helped us know what to do, and how to help---when, where, how, and why. We learned enough about the NICU, all we needed to know, and settled into some routines. We were welcome at bedside practically any time besides shift change, and were sometimes present during rounds, just to listen in. Our nurses encouraged us to go home at night, to take care of ourselves and get some rest, for the sake of the long haul ahead. They told us to call in at any time to check on the baby and say good night, and we did, every night, and the nurse was there with a good word, every time. Days went by, and nurses rotated in and out, caring for John, and it struck me: That nurse was great! And this one is just as good! And they work so well together---to manage the hand-off---and with the doctors too! We learned how healthcare is a team endeavor, an interprofessional domain. The night that John was recovering from his first surgery, we were brought in for a first post-operative visit. I marveled at the ballet before me, the team's movements together, as they monitored the baby, adjusted meds, switched out lines, and completed the perioperative transition. Our surgeon stood stock still at the foot of the bed, watching and offering occasional directions, soft-spoken, as nurses and techs dispatched various duties, following protocols and checklists all their own, all together. That image, of all that concerted activity, is emblematic for me, representing at its best the interprofessional nature of healthcare. That night, with so much at stake, my wife and I took certain refuge in this demonstration. Highly focused professionals working seamlessly together in cooperation and respect. Indirect message: *It's all about the baby. We're on it. Everyone works for the best outcome: For the baby.* Okay. I trust you.

Making Sense of Critical Illness: Medical Decision-Making

Imagine how we felt, my wife and I, first-time parents facing this decision, practically the first we ever made as parents: Thinking about what is best for the baby, did we want to pursue risky and complicated treatment, which *could* allow him to live? Or did we want to keep him comfortable and let him go, sick as he was and hard as his treatments would be, *on him,* over three open-heart surgeries? I remember thinking: *It's not supposed to be like this. How can this be happening? How can I make this choice?*

Family members, faced with surrogate decision-making responsibility, often need support, guidance and basic explanation of their role. Concepts and standards of decision-making, like substituted judgment and best interest, must be explained in clear terms, and surrogates should be provided sufficient counsel and support as they work toward a decision. From a certain angle, every other communication about the patient's condition, all the information sharing and emotional support, and all the relationship- and confidence-building endeavors, are merely preparations for the process and goal of sound decision-making. When the family is well informed about their patient's condition, when they understand its meaning for the patient's quality of life, and when they have the emotional resilience and support to consider things clearly, decision-making will proceed with less difficulty, even if the decision itself is a difficult one, among difficult options.

The morning after his birthday, we visited John in the NICU at the children's hospital, stabilized with a drug (prostaglandin E series) that reopens the ductus. Then we sat with two doctors and a social worker to discuss the decision before us. The surgeon and cardiologist reviewed the long list of things wrong with John's heart, and they explained the surgeries that were indicated. John, if we agreed, would undergo three reconstructive surgeries: In the end, venous blood would bypass his heart altogether and feed directly into his lungs. Oxygenated blood would enter the heart (as normal) through the left atrium; there, however, it would mostly pass over to the right atrium, through the existing atrial septal defect, widened up and made virtuous. Oxygenated blood would flow down into the right ventricle, and the right ventricle (the wrong ventricle!) would pump blood to the body. How? Through the ascending pulmonary artery, now grafted onto a reconstructed and widened aortic arch’s we saw it, eventually, and over-simply, our son would end up with a two-chambered, vaguely amphibian, perhaps reptilian heart: the Amazing Frog Boy! And we owned it: We found baby socks with little froggies on them and brought them to the NICU, and in years to come we dressed him in pajamas decorated with frogs and lizards and turtles, and gave him Kermit the Frog stuffies, and so on.

We consented to treatment, but only after a long discussion. The doctors told us that, given the baby's critical condition, the long road ahead, the burdens and risks of three surgeries, and the uncertain outcome, we had the option of saying no, selecting only comfort care. "Parents in your position sometimes choose comfort care only," they said, neutrally, opening doors without giving directions. Still, that implicit permission sank in hard: Our little boy really *was* that sick.

So we worked through the decision: We reviewed the chances for basic physiological success of treatment (pretty good, at least for the first surgery, given the baby's maturity, healthy birth weight, and relatively simple HLHS presentation). Then we discussed other sorts of risks---neurological outcomes were especially important to us. The doctors talked of how John should not have suffered any anoxic injury as yet, and how such risks are minimized in surgery. They told us about "slow flow" and "no flow" techniques, to slow or even stop the heartbeat for a window of time to work on the tissues, and how they take measures to protect the brain from hypoxia---how for example the body is cooled below normal body temperature, affecting metabolism. I recall that story I heard back in Ohio, the typical story of a kid who fell through thin ice on a frozen pond, lost for half an hour, rescued, revived, to walk away uninjured. And chances are the heart needn't be stopped altogether, anyhow.

We talked about the future, and the sort of life he'd have as a kid and adolescent. Mostly good news: a fairly normal life, most likely. He'll see his share of doctors. He'll have a couple/three trips to the catheterization laboratory as he grows. He won't be a track star. And he won't play contact sports. Not a problem for us, in any case. I thought. He'll have every hope of a decent life. We soon realize: On the children's hospital spectrum, in that frame of reference, we're *lucky*. It's a wonderfully good prognosis: three-year-old boy on a tricycle in the driveway. As for the remote future? No one really knows. At the time, back in 2002, the oldest Norwood kids were barely in their twenties, so it remained to be seen how well these hearts would age. In sum, though, John was judged to be a good candidate for surgery, and should it succeed, he would have a good life.

My wife and I were left alone to talk. We considered all the unforeseen and unpredictable bad things that could happen---all the complications, over three operations, but we stared them down. They were nebulous, where John was crystal clear. Our discussion with the doctors had led us through the right questions, and we considered the necessary things: what it meant for John, how it affected him, and what we risked to get him better. In as many words, under the doctors' guidance, we considered the basic bioethical concepts: John's best interest, the proportionality of benefits and burdens of treatment, and the impact on quality of life. We signed the consent forms, left the conference room, and everybody went to work.

Making Sense of Critical Illness: Preparing for the Future

With information, advice, and support from our nurses and doctors, we made it through the first hours and days. We came to terms with our son's condition, considered the possibilities, and found our way to a treatment decision that felt right to us. Our focus turned to John's recovery and eventual homecoming. We spent nearly three weeks in the NICU, at bedside every day. Here I learned about nurses, and nursing, and what nurses do. At the time I had no real idea. I had been dumb-luck healthy all my life: a couple of nights in the hospital, total, in forty years. I remember riding down to the hospital that first morning, as my friend drove me, wondering what was to come. I knew the doctors would spring into action and do amazing things to save my son: I knew this from TV! But I had no idea about nurses. And yes, over the course of those two years the doctors intervened a half-dozen times and performed seeming miracles to save our baby's life, and I cannot express sufficient thanks for that. What I soon saw was that those calm courageous NICU nurses intervened a half-dozen times *an hour* and performed routine tasks and saved our baby's life time and again, countless times, just by keeping him cozy and warm and well-fed, dosed and diapered and comforted and mothered, all the time and in so many ways we could not. And I saw my future in what they did. I saw the day we would take John home, and I was terrified.

I knew nothing about babies. I was the baby of my family. I had never been near a baby, the day I drove my pregnant wife-in-labor to the hospital. Who was I to take home a baby, much less a baby on seven different meds with a zipper scar and a nasogastric (NG) tube and sat levels of 78 on a good day? But now, here were these NICU nurses, these absolute experts, teaching *me* how to feed, bathe, diaper, medicate, hold, and comfort a baby. They put my wife and me through baby boot camp, basic training, getting us ready to take him home. Here's how to bottle-feed an aerobically deficient little man, too tired to suckle, each sip a victory, and here's how to send the rest of the feeding down the nasogastric tube, to baby's little belly. Here's how to crush an aspirin to dust, and mix it with some breast milk, and suck it into a syringe, and squirt it into baby's mouth. Here's how to get the poo out of all those wrinkles, fat little baby fats. Here's how to draw the meds without getting bubbles in the oral syringe. Here's how to wrap the baby in a blanket so he feels happy and safe and looks like a baby-filled burrito. Here's how to replace that NG tube *again*, weeks later, the third time he's pulled it out and we're down at the hospital again. Babies don't like NG tubes, and they have ways of getting that little pinky finger under that tape to pull it out. This time, teach me how to put it back in. (And they did.)

Thus: Almost three weeks later, the day came, and we took our baby home. I half-believed that we could do this, my wife and I, as we took over his care. In fact, our nurses had trained us well: We managed. John was on seven medications on an every-three-hour dosing schedule, 24 hours a day, lined up with his feeding schedule, 30 ml of EBM every three hours. My wife pumped as I fed the baby and administered medications, around the clock. With his makeshift circulation, after stage one; his saturation levels were at 72-75%. Breastfeeding was beyond him, too much work, so my wife pumped milk (for six months!) and I prepared the bottle, and John drank about half of his feeding before passing out, and the rest went down the nose hose. And we measured out the doses and kept up his meds and managed his feedings and he made it. And we did too. We took over for the nurses and nursed our child together, in every meaning of the word. Five months went by, and it was time for the next surgery.

And again we made it, and again, through stages two and three, and today our son is a normal adolescent, scowling and angry and bored---the way it should be. Years later, now I see how clever they were, those nurses: They welcomed us into the NICU so that we could get to know our son, get to know them, and get to know how to get along without them, eventually. All along they were coaching us, training us, and modeling good care. They taught us not just how to change a diaper, draw meds, or feed a baby through a tube: They taught us how to be tough-minded and caring at once, and believe in our baby's recovery. They taught us that we could do all this, mostly by doing it themselves, as we watched and listened and learned. Thanks to their care, we could take over. Now it made sense. We were ready, and we made it.

Conclusion

This case study exemplifies the key role that nurses play in promoting FCC. While support for family centered care with the promotion of open visitation, family participation on rounds, and family presence during invasive procedures or resuscitation varies internationally, there is an increasing focus globally in promoting FCC.

FCC is important to help families through the crisis of critical illness. The nurse's role in encouraging family presence and engagement, assuring information needs are met, developing caring relationships, promoting family bonding and preserving family integrity may minimize or prevent PICS-F and optimize caregiving required after discharge from the ICU. A structured approach to FCC set out in a policy, standards of care or organizational guideline is advocated. A monitoring program to assure compliance with FCC standards is advised. The FS-ICU may be used to gather direct feedback on unit performance from ICU families. Both the Quality Caring Model and Facilitated Sensemaking mid-range theory of nursing can help nurses understand how to apply the principles of FCC in practice. As the family plays an essential role in promoting recovery from critical illness, advancing the involvement of families and advocating for FCC in the ICU is a priority area for nurses worldwide.

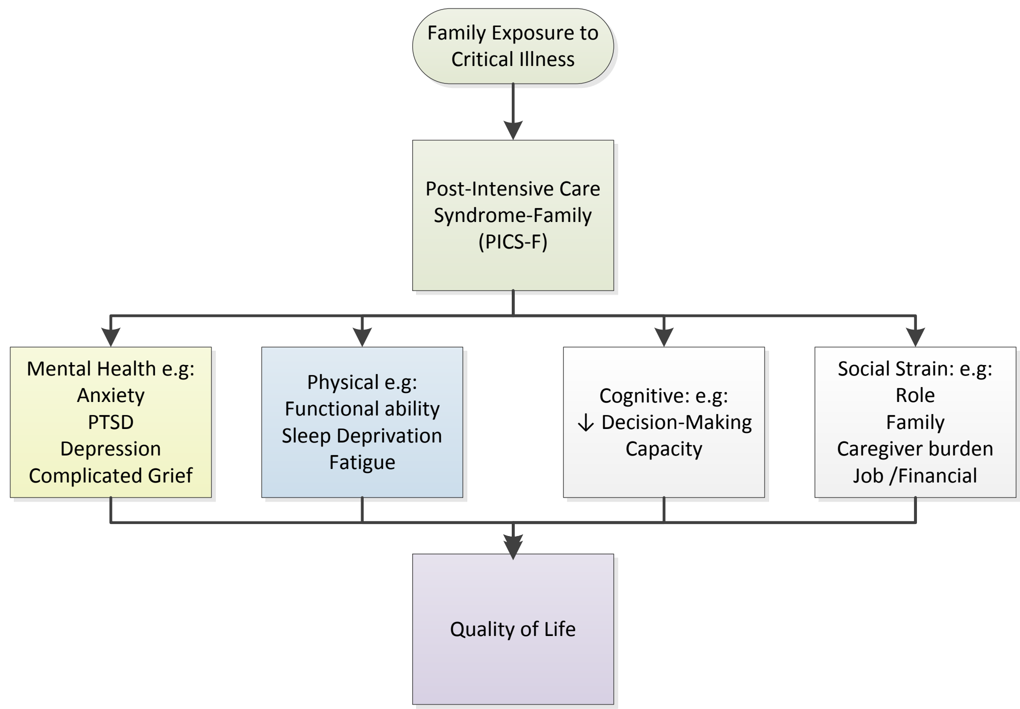

Figure 10-3: Post-Intensive Care Syndrome-Family (PICS-F)

Legend: PTSD= Post Traumatic Stress Disorder

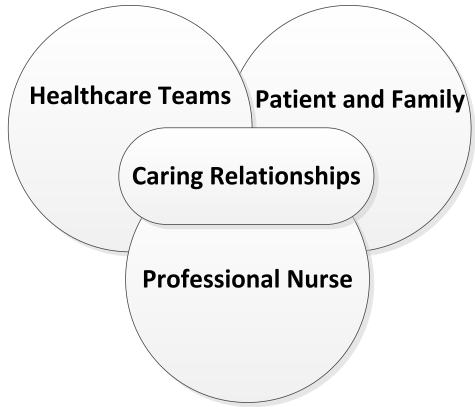

Figure 10-4: Caring Relationships: The Core of Quality Nursing Caring. Adapted with permission from (Duffy, 2013).

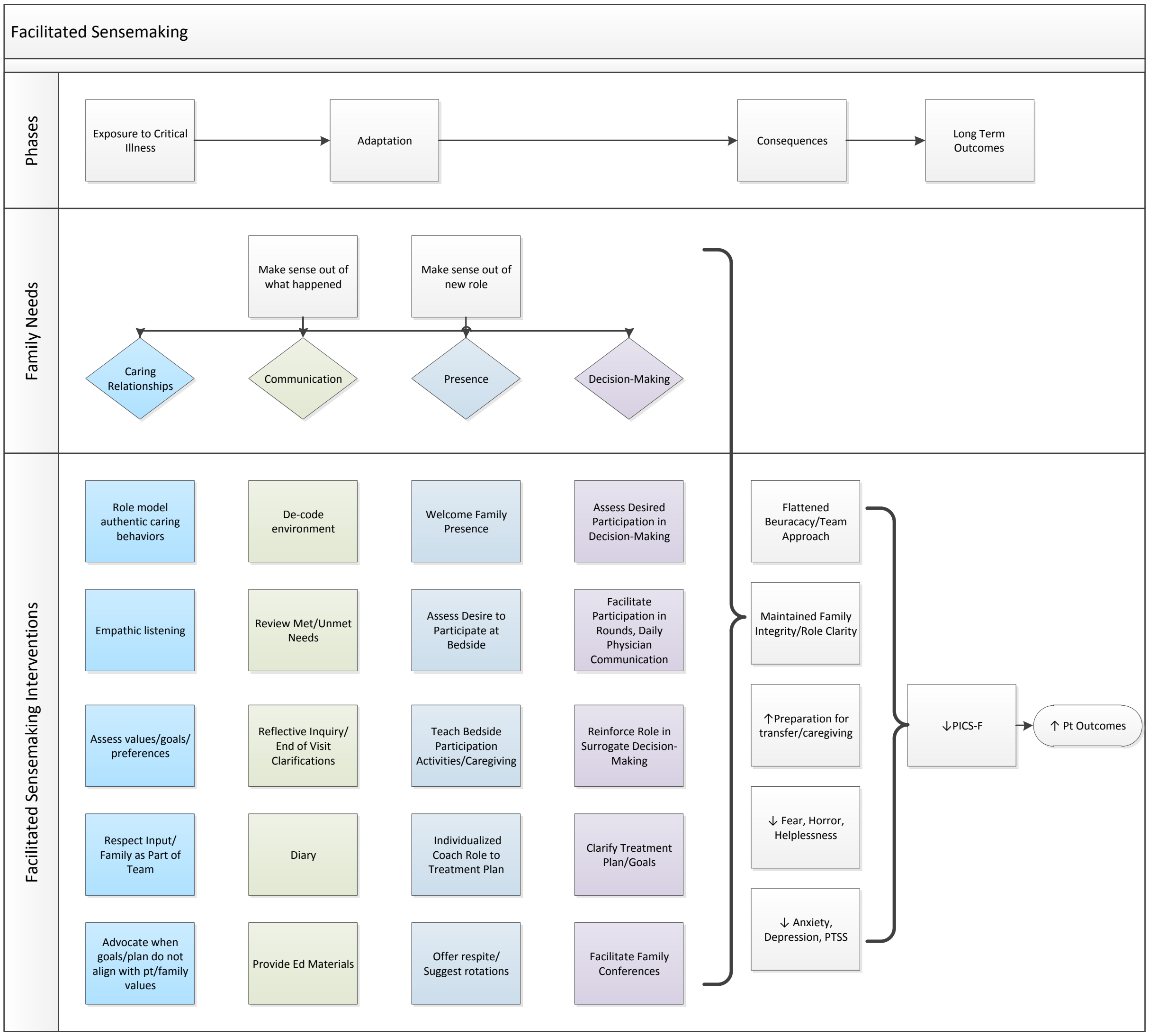

Figure 10-5: Facilitated Sensemaking Conceptual Model

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Chapter 11

Arrhythmias and Cardiac Emergencies

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Introduction

Arrhythmia interpretation and care of patients experiencing acute cardiac events is a foundational competency required of registered nurses working in critical care. The aim of this chapter is to provide a resource for critical care nurses internationally that will assist with recognition of key characteristics of sinus, atrial, junctional, ventricular arrhythmias and atrioventricular (AV) blocks. In addition, evidence-based care will be discussed in relation to symptomatic arrhythmias and cardiac emergencies such as myocardial infarction and cardiac arrest. The chapter will conclude with practice questions and a case study. Helpful websites and further resources will also be provided. The intention of the chapter is to provide an overview of the key components of basic arrhythmias and a summary of treatment. The chapter is designed to accommodate learners that have a good understanding of cardiac anatomy and physiology in addition to an introductory level of understanding of cardiac arrhythmias.

Arrhythmia Interpretation: Where do I start?

The first part of accurately interpreting arrhythmias is to use a *Systematic Approach* (see Figure1). However, before you begin to analyze the rhythm strip, ALWAYS check the patient first and ensure the patient is stable.

Table 11-1: Systematic Approach to Interpreting Arrhythmias

Steps	Explanation
1. Regularity	Assess whether the rhythm is regular or irregular
2. Rate	Calculate ventricular and atrial rate
3. Assess p waves	Are the p waves: rounded, symmetrical, one for every QRS, all look the same?
4. Calculate pr interval (pri)	Normal=.12-.20 seconds
5. Calculate QRS interval	Normal= .06-.10 seconds
6. Assess ST segment	The ST segment should be on the baseline or ‘isoelectric’ line. If it is elevated or depressed it could mean cardiac injury or ischemia and requires urgent further assessment. In addition, the physician should be notified immediately since this could indicate that the patient could be experiencing an MI.
7. Interpret the arrhythmia	Name the arrhythmia based on the characteristics above (i.e. atrial fibrillation)
8. Nursing Intervention/Treatment Required	Determine what intervention is required. Is the patient stable of unstable? Should the physician be notified?

Normal Sinus Rhythm

In order to analyze cardiac rhythms, it is essential to have an understanding of the 'benchmark' rhythm or hemodynamically perfect rhythm; which is referred to as Normal Sinus Rhythm and sometimes abbreviated to NSR. In order to be considered Normal Sinus Rhythm, the rhythm must have the following characteristics:

Table 11-2: Characteristics of Normal Sinus Rhythm

Rhythm	Regular
Rate	60-100/minute
p waves	Present, upright, symmetrical, one before every QRS
pri	.12-.20 seconds
QRS	.06-.10 seconds

If the rhythm has all of the above characteristics but the ST segment is elevated, it would be referred to as sinus rhythm with an elevated ST segment versus 'normal' sinus rhythm.

Sinus Rhythms

In the next section, arrhythmias originating in the sino-atrial (SA)node will be explored. The characteristics, causes, nursing implications and treatment required for sinus bradycardia, sinus tachycardia, sinus arrhythmia and wandering atrial pacemaker will be presented.

Slow Rhythms: Sinus Bradycardia

A patient is considered to be bradycardic when their heart rate drops below 60 beats per minute. Generally, a person often becomes symptomatic when their heart rate drops below 50 beats/minute, however slower heart rates can be observed in fit & athletic individuals, who will often remain asymptomatic. As a general rule, when a patient's heart rate is less than 60/minute critical care nurses should be prepared to immediately assess for signs of decreased cardiac output (i.e. decreased level of consciousness, hypotension, chest pain).

Table 11-3: Characteristics of Sinus Bradycardia

Rhythm	Regular
Rate	< 60/minute
p waves	Present, upright, symmetrical, one before every QRS
pri	.12-.20 seconds
QRS	.06-.10 seconds
Cause	Parasympathetic stimulation (i.e. medications, vomiting, suctioning, bearing down) Also hypoxemia
Treatment	Only treated if patient is symptomatic. If symptomatic, Atropine administered IV bolus is the treatment of choice If the patient becomes unstable (i.e. exhibits symptoms of chest pain, heart failure, syncope or a reduced level of consciousness) an intravenous chronotrope infusion (such as Epinephrine or Dopamine) or external transcutaneous pacing should be considered

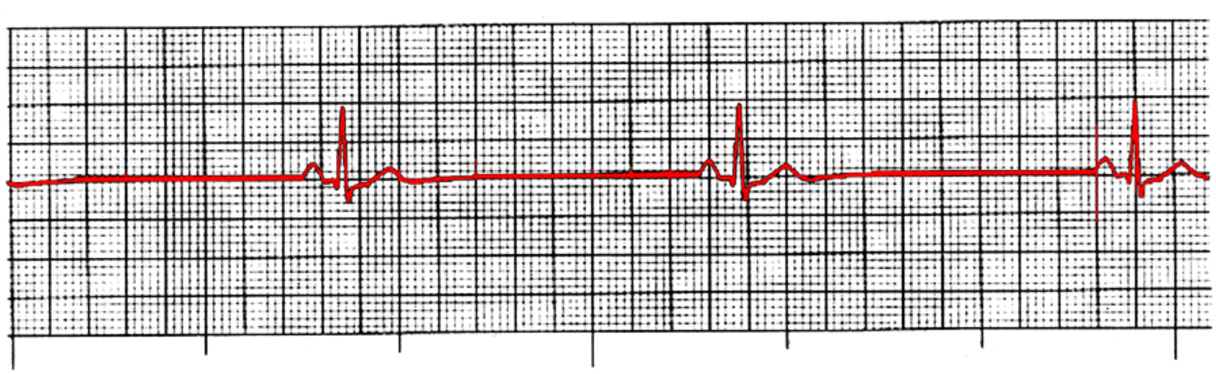

Figure 11-2: Sinus Bradycardia

Fast Rhythms: Sinus Tachycardia

A patient is considered tachycardic when their heart rate rises above 100/minute, although typically individuals do not experience symptoms until the heart rate climbs above 150/minute. It is best practice for a critical care nurse to assess for signs and symptoms of decreased cardiac output (i.e. hypotension, decreased level of consciousness) when the heart rate is greater than 100/minute since this could result in patients developing cardiac ischemia, angina or even a myocardial infarction.

Table 11-4: Characteristics of Sinus Tachycardia

Rhythm	Regular
Rate	>100/minute
p waves	Present, upright, symmetrical, one before every QRS
pri	.12-.20 seconds
QRS	.06-.10 seconds
Cause	Sympathetic stimulation (i.e. medications, pain, fever, anxiety, shock) Also hypoxemia ** typically gradual in onset versus paroxysmal
Treatment	Treatment is aimed at treating the underlying cause (i.e. intravenous fluids for hypovolaemia or analgesics for acute pain)

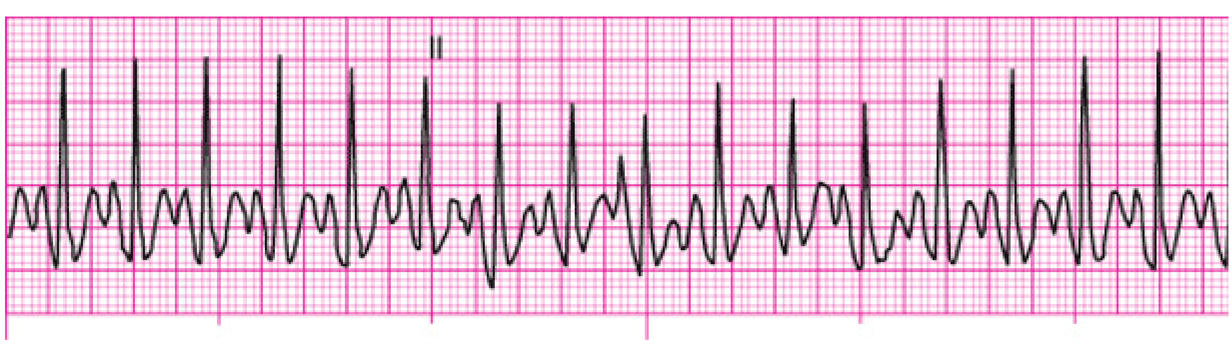

Figure 11-3. Sinus Tachycardia

Irregular Rhythms: Sinus Arrhythmia and Wandering Atrial Pacemaker (WAP)

The next two arrhythmias, sinus arrhythmia and wandering atrial pacemaker are typically benign and do not require treatment.

Table 11-5: Characteristics of Sinus Arrhythmia

Rhythm	Irregular
Rate	60-100/minute
p waves	Present, upright, symmetrical, one before every QRS
pri	.12-.20 seconds
QRS	.06-.10 seconds
Cause	Can be a normal aberration Seen in children and also in mechanically ventilated patients
Treatment	No treatment required Observe for further arrhythmia development

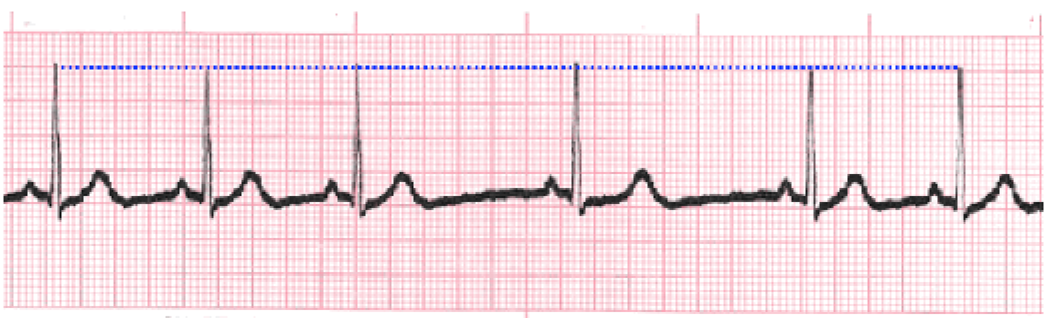

Figure 11-4 Sinus arrhythmia

Table 11-6: Characteristics of Wandering Atrial Pacemaker

Rhythm	Regular or slightly irregular
Rate	60-100/minute
p waves	P waves vary in shape and size
pri	.12-.20 seconds
QRS	.06-.10 seconds
Cause	Can be a normal aberration Ischemia
Treatment	No treatment required

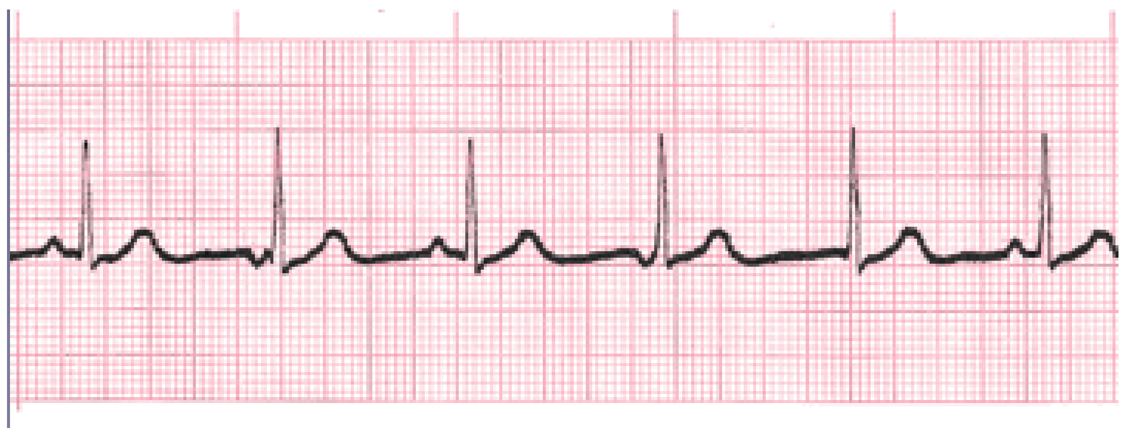

Figure 11-5: Wandering Atrial Pacemaker

Atrial Rhythms

In the next section, rhythms originating in the atria will be explored. These arrhythmias include: premature atrial contractions, atrial flutter, atrial fibrillation and supraventricular tachycardia. Key characteristics of these rhythms will be identified along with nursing implications and helpful tips to assist critical care nurses in accurately interpreting atrial arrhythmias.

Table 11-7: Premature Atrial Contractions (PACs)

Rhythm	Early beat (PAC) causes rhythm to be irregular
Rate	Underlying rhythm usually 60-100/minute
p waves	P waves have different configuration than underlying rhythm
pri	.12-.20 seconds in underlying rhythm
QRS	.06-.10 seconds in underlying rhythm
Cause	Can be a normal aberration Ischemia Or a signal of atrial irritability- can lead to more serious atrial rhythms
Treatment	No treatment required for isolated PACs Assess for increasing PACs since this indicates increasing atrial irritability and underlying cause (i.e. hypovolemia, hypervolemia or electrolyte imbalance) needs to be treated

Figure 11-6: Premature atrial contractions

Table 11-8: Characteristics of Atrial Flutter

Rhythm	Regular or irregular
Rate	60-100/minute (ventricular rate) 250-400 (atrial rate)
p waves	No p waves present Flutter waves (F waves) or 'sawtooth' waves
pri	No pri since no p wave
QRS	.06-.10 seconds
Cause	Electrolyte imbalance Hypertension Ischaemic heart disease Congenital heart disease Rheumatic valve disease Following cardiac surgery
Treatment	Anticoagulation should be considered due to the risk of atrial thrombus formation. Medications for rhythm and rate are recommended. Cardioversion or ablation may also be considered.

Figure 11-7: Atrial Flutter

Table 11-9: Characteristics of Atrial Fibrillation

Rhythm	Irregular
Rate	60-100/minute (ventricular rate) >400/minute (atrial rate)
p waves	No p waves Fibrillatory waves (f waves)
pri	No pri since no p waves
QRS	.06-.10 seconds
Cause	Electrolyte imbalance Hypertension Ischaemic heart disease Congenital heart disease Rheumatic valve disease Following cardiac surgery
Treatment	Anticoagulation should be considered due to the risk of atrial thrombus formation. Medications for rhythm and rate are recommended. Cardioversion or ablation may also be considered.

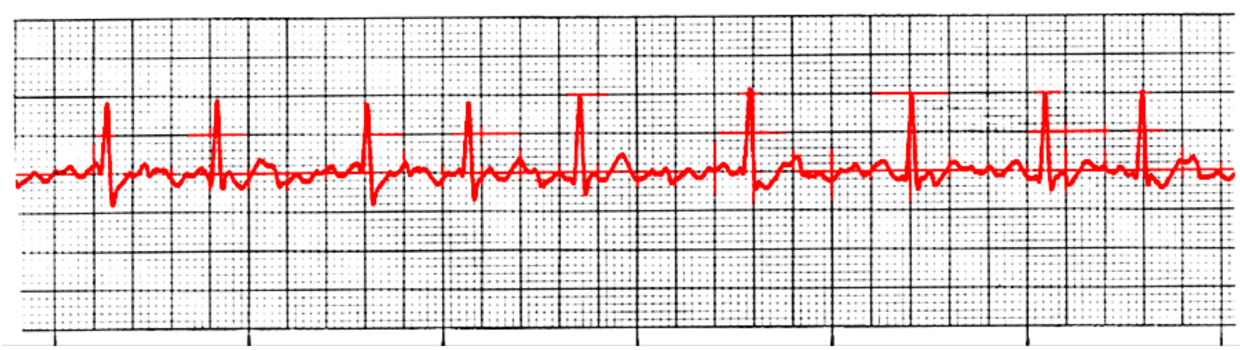

Figure 11-8: Atrial Fibrillation

Table 11-10: Characteristics of Supraventricular Tachycardia (SVT)

Rhythm	Regular
Rate	150-250/minute
p waves	P waves may not be seen at higher rates
pri	.12-.20 seconds (if seen)
QRS	.06-.10 seconds
Cause	Congenital heart disease Emotional stress Physical stress or exertion Illegal drugs (i.e. Cocaine or ecstasy) Alcohol Caffeine
Treatment	Urgent expert referral Oxygen administration if required Intravenous access Vagal maneuvers (i.e. carotid sinus massage or Valsalva maneuver) Intravenous Adenosine Other rate controlling agents may be considered if the patient is not haemodynamically compromised

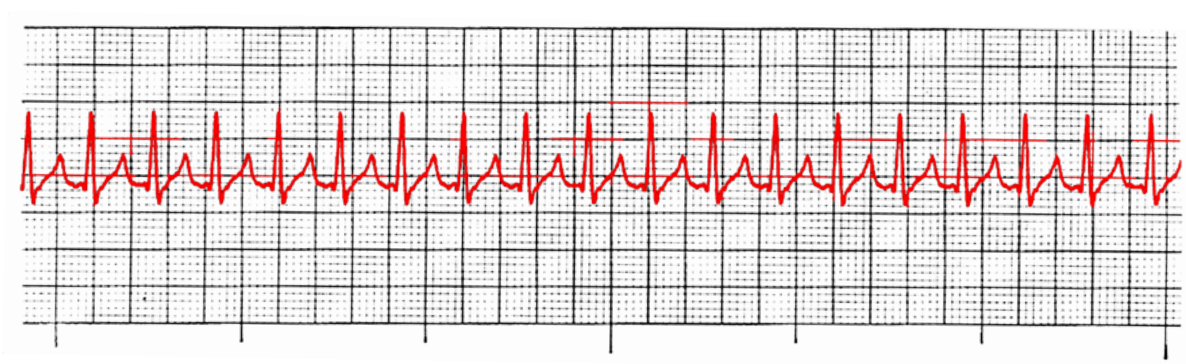

Figure 11-9: Supraventricular Tachycardia

Junctional Rhythms

Junctional rhythms originate in the AV node or junctional area and are typically transient and non-lethal. The rhythms that will be presented in this section include: premature junctional contractions, junctional rhythm, accelerated junctional rhythm and paroxysmal junctional tachycardia. All junctional rhythms have the common feature of inverted p waves although in some cases the p waves are not seen since the depolarization of the atria is occurring close to the time that the ventricles are being depolarized. Junctional rhythms are simply differentiated by rate since they possess the same characteristics.

Table 11-11: Premature Junctional Contraction (PJC)

Rhythm	Early beat (PJC) causes the rhythm to be irregular
Rate	60-100/minute (underlying rhythm)
p waves	P waves inverted or not seen in PJC
pri	Not applicable
QRS	.06-.10 seconds (in underlying rhythm)
Cause	Medication toxicity (i.e. digoxin) Ischemia
Treatment	No treatment required Continue to observe for increasing number of PJCs since this indicates increasing AV node irritability

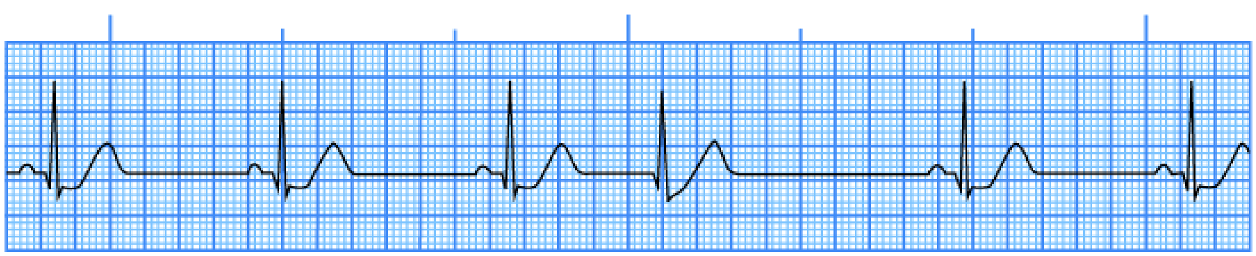

Figure 11-10: Premature Junctional Contractions

Table 11-12: Characteristics of Junctional Rhythm

Rhythm	Regular
Rate	<60/minute
p waves	P waves inverted or absent
pri	.12-.20 seconds
QRS	.06-.10 seconds
Cause	Medication toxicity (i.e. digoxin) Ischemia
Treatment	Treat cause

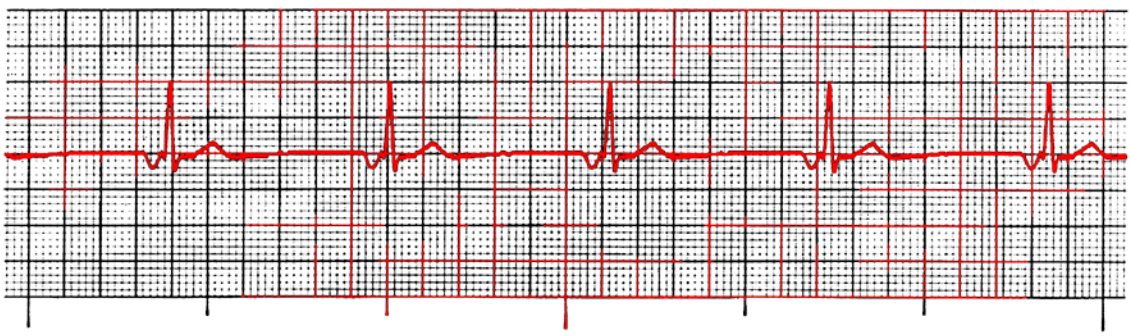

Figure 11-11: Junctional Rhythm

Table 11-13: Characteristics of Accelerated Junctional Rhythm

Rhythm	Regular
Rate	60-100/minute
p waves	P waves inverted or absent
pri	Not applicable
QRS	.06-.10 seconds
Cause	Medication toxicity (i.e. digoxin) ischemia
Treatment	Treat cause

Figure 11-12: Accelerated Junctional Rhythm

Table 11-14: Characteristics of Paroxysmal Junctional Tachycardia (PJT)

Rhythm	Regular
Rate	150-250/minute
p waves	P waves inverted or absent (if seen)
pri	Not applicable
QRS	.06-.10 seconds
Cause	Ischemia
Treatment	See SVT

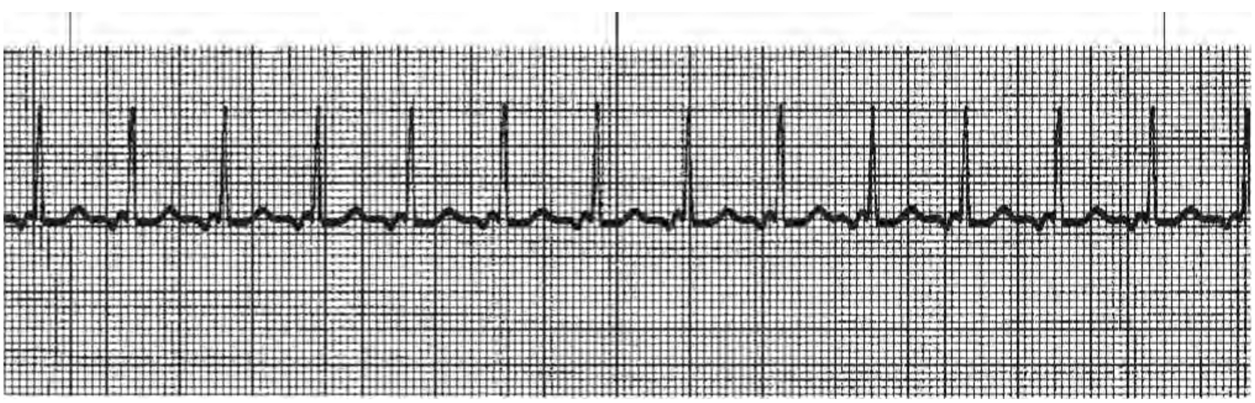

Figure 11-13: Paroxysmal Junctional Tachycardia

Ventricular Rhythms

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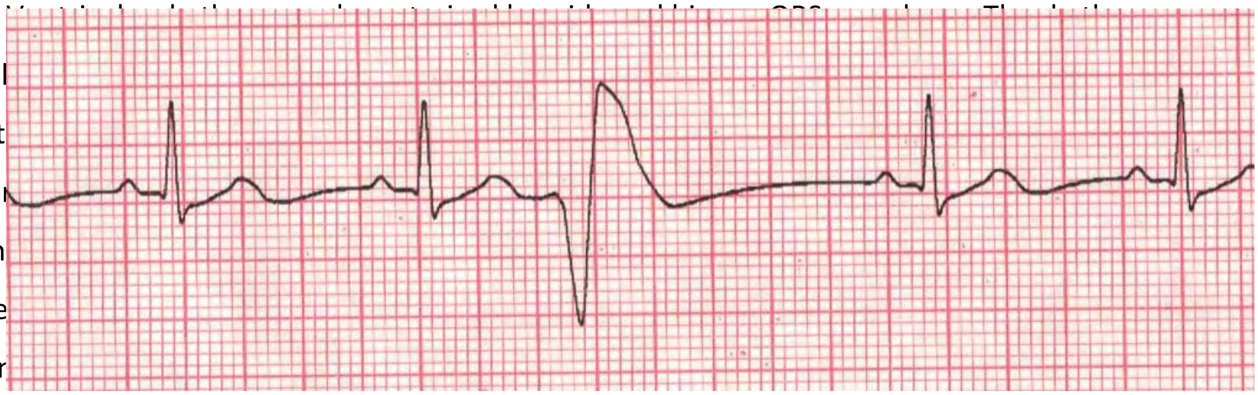

Table 11-15: Characteristics of Premature Ventricular Contractions (PVCs)

Rhythm	Early beat (PVC) causes the rhythm to be irregular
Rate	60-100/minute (underlying rhythm)
p waves	None (in PVC)
pri	None (in PVC)
QRS	> .12 seconds (wide and bizzare)
Cause	Ventricular irritability (i.e.hypoxemia, acid-base imbalance, medications, electrolyte imbalance)
Treatment	No treatment required for isolated PVCs Watch for an increase in PVCs (> 10/minute) since this indicates an increase in ventricular irritability Note morphology and incidence of PVC's & escalate if required (i.e. PVC's could be multifocal, unifocal, couplets, bigeminal or trigeminal.

Figure 11-14: Premature Ventricular Contractions

Table 11-16: Characteristics of Ventricular Tachycardia (VT)

Rhythm	Regular
Rate	150-250/min
p waves	none
pri	none
QRS	> .12 seconds (wide and bizzare)
Cause	Ventricular irritability (i.e.hypoxemia, acid-base imbalance, medications, electrolyte imbalance)
Treatment	Confirm signs of life (i.e. presence of pulse & normal respiratory effort) Obtain emergency assistance (i.e. cardiac arrest or rapid response team if available) <u>If no signs of life (pulseless VT):</u> Commence basic life support in accordance to national resuscitation guidelines (chest compressions and ventilation breaths) Defibrillate as per national resuscitation guidelines Secure intravenous access & administer Epinephrine & Amiodarone as per guidelines <u>If signs of life are noted (VT with a pulse):</u> Administer oxygen as required Obtain intravenous access Administer intravenous Amiodarone Correct abnormal electrolytes

Figure 11-15: Ventricular Tachycardia

Table 11-17: Characteristics of Ventricular Fibrillation (VF)

Rhythm	Irregular and chaotic
Rate	Cannot calculate
p waves	none
pri	none
QRS	none
Cause	Ventricular irritability (i.e.hypoxemia, acid-base imbalance, medications, electrolyte imbalance)
Treatment	Confirm signs of life (i.e. presence of pulse & normal respiratory effort) Obtain emergency assistance (i.e. cardiac arrest or rapid response team if available) Commence basic life support in accordance to national resuscitation guidelines (chest compressions and ventilation breaths) Defibrillate as per national resuscitation guidelines Secure intravenous access & administer Epinephrine & Amiodarone as per guidelines

Figure 11-16: Ventricular Fibrillation

Table 11-18: Characteristics of Idioventricular Rhythm

Rhythm	Regular
Rate	<40/minute
p waves	No p waves
pri	No pri
QRS	> .12 seconds (wide and bizarre)
Cause	Ischemia, reperfusion post thrombolytics
Treatment	Typically benign, transient However if the patient exhibits signs of haemodynamic compromise, treat with interventions listed for bradycardia: atropine, chronotropic agents (intravenous infusion of Epinephrine), transcutaneous pacing.

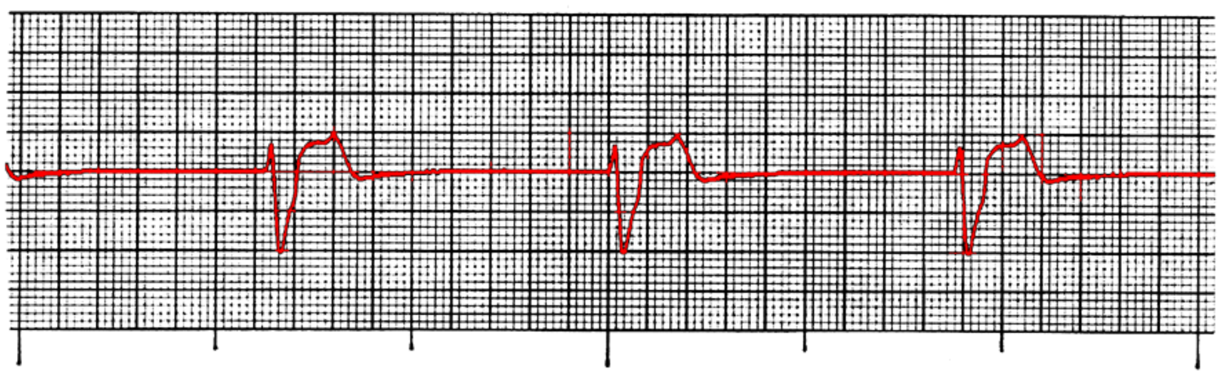

Figure 11-17: Idioventricular Rhythm

Table 11-19: Characteristics of Accelerated Idioventricular Rhythm (AIVR)

Rhythm	Regular
Rate	40-100/minute
p waves	No p waves
pri	No pri
QRS	> .12 seconds (wide and bizarre)
Cause	Reperfusion, ischemia
Treatment	Typically transient, no treatment required

Figure 11-18: Accelerated Idioventricular Rhythm

Table 11-20: Characteristics of Aganol Rhythm

Rhythm	very irregular
Rate	< 40/minute
p waves	No p waves
pri	No pri
QRS	> .12 seconds seconds
Cause	End stage cardiac disease
Treatment	This rhythm technically indicates a refractory end of life situation

Figure 11-19: Aganol Rhythm

AV Blocks

Atrioventricular (AV) blocks are characterized by electrical conduction dysfunction through the myocardium. This is manifested as obstructed, delayed or variable electrical conduction through the AV node. Types of AV block include: 1st degree heart block, 2nd degree heart block (Mobitz type 1 or Wenkebach), 2nd degree heart block (Mobitz type 2) and 3rd degree heart block (complete heart block). AV blocks can be associated with significant risk deterioration or haemodynamic compromise, so prompt identification and treatment is vital for the critical care nurse. Characteristics of each AV block will be explored, including nursing considerations and treatment options.

Table 11-21: First Degree AV Block

Rhythm	Regular
Rate	60-100/minute
p waves	P waves normal
pri	>.20 seconds
QRS	.06-.10 seconds
Cause	AV nodal disease Enhanced vagal tone (i.e. athletes) Myocarditis Following Myocardial Infarction Electrolyte disturbances Medications (i.e. Calcium channel blockers, Beta blockers)
Treatment	No treatment required Observe for further block

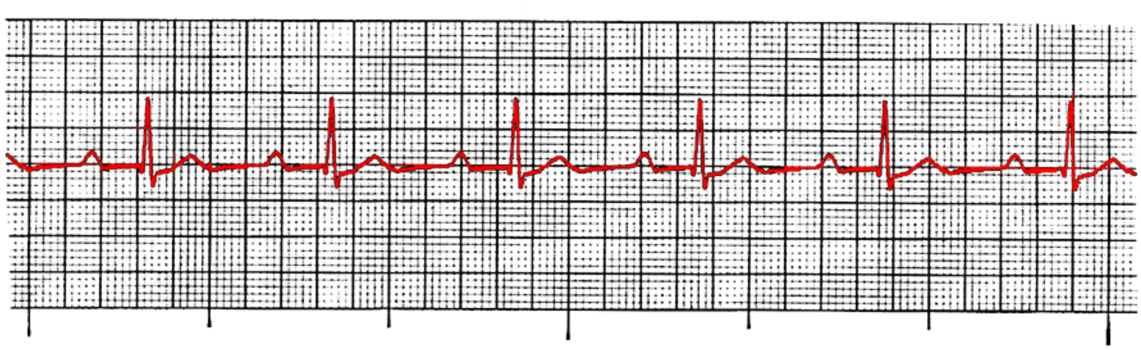

Figure 11-20: First Degree Heart Block

Table 11-22: Characteristics of Second Degree Type I

Rhythm	Regular or slightly irregular
Rate	60-100/minute
p waves	P waves normal
pri	Progressively gets longer until a beat is dropped
QRS	.06-.10 seconds
Cause	Ischemia
Treatment	Usually benign, with no treatment required If patient becomes haemodynamically compromised consider interventions for bradycardia Observe for worsening AV block

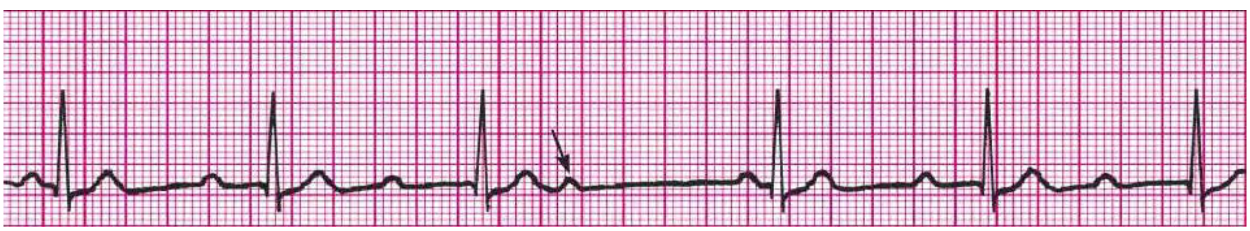

Figure 11-21: Second Degree Type I

Table 11-23: Characteristics of Second Degree AV Block Type II

Rhythm	Regular or irregular
Rate	varies
p waves	More p waves than QRS complexes
pri	constant
QRS	.06-.10 seconds or may be widened
Cause	Ischemia, MI
Treatment	If patient becomes haemodynamically compromised consider interventions for bradycardia Observe for worsening AV block May require temporary or permanent pacing

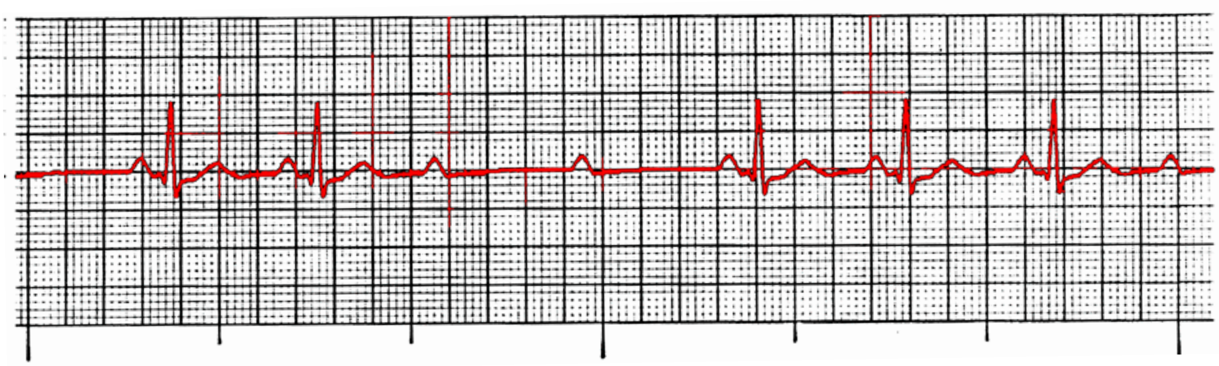

Figure 11-22: Second Degree AV Block Type II

Table 11-24: Characteristics of Third Degree Heart Block

Rhythm	Ventricular rhythm regular (R-R) and atrial rhythm regular (p-p)
Rate	Ventricular rate typically <40/min and atrial rate 60-100/minute
p waves	No relationship between p waves and QRS complex
pri	Not applicable
QRS	Usually >.12 seconds but may be normal
Cause	Ischaemic heart disease Following Myocardial Infarction Lyme disease Congenital
Treatment	If patient becomes haemodynamically compromised consider interventions for bradycardia May require temporary or permanent pacing

Figure 11-23: Third Degree Heart Block

Summary

In this chapter, a systematic approach was presented for interpreting arrhythmias. This approach should be routinely used to ensure accurate interpretation of arrhythmias when caring for your critically ill patient. In the event that the patient is hemodynamically unstable or unresponsive, the first priority would be to assess the patient first and provide emergency treatment. For further development in your skill in interpreting basic arrhythmias, we recommend continued development by further rhythm practice and attendance at arrhythmia refresher courses when possible. In addition, we have provided resources at the end of this chapter that we hope you find helpful as you develop further competency in this subject area.

Practice Questions- Test Yourself!

Below you will find a case study and several practice questions to test your knowledge after reviewing this chapter.

Case Study

Mr Mohammed Ahmed is a 59 year male, who has presented to his local hospital with severe central, crushing chest pain. He has a past medical history of diabetes, hypertension and a high body mass index. On admission to hospital, Mr Ahmed's ECG, clinical presentation & blood results confirm a diagnosis of an inferior ST elevation myocardial infarction (STEMI), then then proceeds to the cardiac catheterization lab for primary percutaneous coronary intervention (PPCI). During the procedure, the cardiac catheterization lab team notes a cardiac rhythm change:

This rhythm change is treated immediately and the patient returns to normal sinus rhythm (NSR) at a rate of 90 beats per minute. Following the procedure, Mr Ahmed is transferred to the cardiac care unit. He recovers well following his STEMI & PPCI, however the following day a further rhythm change is noted by the nursing team:

Mr Ahmed becomes symptomatic with this new cardiac rhythm, with profound hypotension (BP of 68/45mmHg) and a reduced level of consciousness. The physician attends and requests emergency interventions.

Multiple Choice Questions:

1. Concerning the first rhythm (Ventricular Fibrillation). What key treatment interventions are required immediately?

    a. Epinephrine & cardiopulmonary resuscitation (CPR).

    b. Cardiopulmonary resuscitation (CPR), defibrillation.

    c. Confirmation of cardiac arrest, cardiopulmonary resuscitation (CPR) and defibrillation.

    d. Transcutaneous pacing.

Answer: c. Confirmation of cardiac arrest, cardiopulmonary resuscitation (CPR) and defibrillation. Artifact or patient movement can mimic ventricular fibrillation (VF), to it is vital that the healthcare professional confirms cardiac arrest prior to calling for assistance, commencing CPR or initiation of defibrillation. Cardiopulmonary resuscitation (CPR) should be initiated immediately to ensure that key organs remain perfused. Once a defibrillator is available, the patient should receive a shock, followed by further CPR.

2. Ventricular fibrillation (VF) should be described by which statement?

    a. A regular, fast rhythm, which is characterized by a wide QRS & no clear P wave activity.

    b. An irregular, chaotic fast rhythm, which features no clear P wave or QRS complexes.

    c. An irregular, fast rhythm, which has fibrillatory P waves and normal QRS complexes.

    d. A regular, normal speed rhythm, which is characterized by clear P wave activity and normal QRS complexed.

Answer: b. Ventricular fibrillation (VF) can be described as a complex, irregular and chaotic rhythm, which features no clear P waves and QRS complexes that have a random width and amplitude. VF is a cardiac arrest rhythm and warrants immediate CPR and defibrillation.

3. Concerning management of the 2nd cardiac rhythm & Mr Ahmeds deterioration, what interventions are required?
   a. Commence cardiopulmonary resuscitation (CPR) & defibrillate.
   b. Administer an intravenous fluid bolus.
   c. Administer intravenous Atropine. If no improvement, consider transcutaneous pacing via a pacing enabled defibrillator.
   d. Commence an intravenous infusion of Epinephrine.

Answer: c. Mr Ahmed's rhythm deteriorated into Sinus Bradycardia (SB). Treatment for symptomatic bradycardia includes administration of intravenous Atropine. If Atropine fails to achieve a satisfactory result, transcutaneous pacing can be implemented via a pacing enabled defibrillator.

Other Helpful Resources

Ecglibrary.com (for practice)

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Chapter 12

Nursing Sensitive Outcomes Indicators (NSOIs)

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Focusing on improving care in the intensive care unit (ICU) is an acknowledged priority area for critical care nurses internationally. This chapter addresses prevention of adverse events in the ICU including patient falls, displacement of tubes (endotracheal/tracheostomy) line and drains, and medication errors as well as patient and family satisfaction . Collectively, these nursing sensitive outcome indicators are global areas of focus for critical care nurses. Exemplars are provided to highlight the important role that critical care nurses play in improving quality of care in the ICU by using nursing sensitive outcome indicators.

Learning Outcomes

After completing this e-chapter you will be able to:

1) Identify the characteristics of Nursing Sensitive Outcomes Indicators;
2) Review the definitions of fall, displacement of tubes/lines/drains and medication incidents;
3) Understand the risk factors of falls in intensive care;
4) Highlight strategies of fall prevention;
5) Discuss recommendations for minimizing the chance of displacement of tube/line/drains;
6) Explain the types and causes of medication errors in intensive care unit;
7) Discuss strategies for improving medication safety;
8) Identify evidence-based interventions that are effective in enhancing patient and family satisfaction;
9) Discuss the role of the nurse in promoting improved care in the ICU using nursing sensitive outcome indicators.

Overview

The dawn of the twenty-first century marks a new era for the entire nursing profession. To keep pace with the ageing population; advanced technology; rising public expectation; escalating healthcare costs; and the advent of modern medicine; coupled with the need to achieve improvement in healthcare quality and safety, clinical nurses, and nurse executives are increasingly concerned about measuring the outcomes of care in their workplace and gathering evidence to justify their decisions for resources allocation. The growing sophistication of the health care systems everywhere calls for an increased emphasis on evidence and outcomes. Gallagher & Rowell (2003) opined that "The provision of outcome-oriented, cost-effective health care is no longer a goal. It is a mandate. To accomplish this mandate, the relationship between the costs, quality and desired outcomes of care, and the processes involved in providing care must be reexamined." Successful indicators that capture nursing-sensitive patient outcomes tie together research findings and best practices in an effort to create better patient care.

What are Nursing Sensitive Outcome/Quality Indicators?

The American Nurses Association (1996) defined Nursing-sensitive Quality Indicators as those indicators that capture care or are most affected by nursing care**.** The use of **nurse sensitive quality indicators** in Intensive Care Units (ICU) has been as a tool to show the clear linkages between nursing interventions, staffing levels, and positive patient outcomes. Nursing Sensitive Quality Indicators (NSQIs) and Nursing Sensitive Outcomes Indicators (NSOIs) are referring to the same thing - patient outcomes that are directly or indirectly influenced by nursing (Dorman, 1977).

In 1998, American Nurses Association (ANA) funded the development of a National Database named as the National Database of Nursing Quality Indicators (NDNQI). Its goals are to promote and facilitate the standardization of information submitted by hospitals across the United States on nursing quality and patient outcomes. Yang et al. (1999) defined NSOI as "…changes in health status upon which nursing care has had a direct influence". The International Council of Nurses (ICN 2001) stated it as "… the measure or status of a nursing diagnosis at points in time after a nursing intervention. Nursing-sensitive indicators are specific to nursing and differ from medical indicators of care quality. As such, nursing outcomes indicators are those outcomes most influenced by nursing care" (Montalvo, 2007).

NDNQI began formally collecting data related to ten NSQIs for Acute Care Settings include:

1. Total Nursing Care Hours provided per patient day
2. Mix of RNs, LPNs & unlicensed staff caring for patients in Acute Care Settings

3. Pressure Ulcers
4. Nursing Staff Satisfaction
5. Nosocomial Infection Rate (bacteremia's associated with central lines)
6. Patient Falls
7. Patient Satisfaction with Overall Care
8. Patient Satisfaction with Educational Information
9. Patient Satisfaction with Pain Management
10. Patient Satisfaction with Nursing Care

    (Nursing Administration Quarterly 2003 & Nursing World, ANA Indicator History 2015)

The recommended definitions of the ten indicators can be found in ANA's 2015 publication. In this chapter fall displacement of tubes/lines/drains, medication incidents and patient/family satisfaction and related indicators will be discussed as it relates to critical care nursing.

The Joint Commission started incorporating NSOIs into its standards for accreditation. Nowadays, nursing-sensitive indicators are widely used.

As an example of how NSOI can be used to monitor nursing impact, data collection for NSOIs in ICUs started in 2005 in Hong Kong. Currently fifteen ICUs in public hospitals (at Level II and above) in Hong Kong contribute to this database.

Hong Kong established a set of Specialty Guidelines for ICU nurses in which service indicators were listed as follows:

Patient-focused Outcomes Indicators listed in the Specialty (ICU) Guidelines:

Treatment/Care Modality Indicators

Adverse Incident rates such as medication incident rate, patient fall rate and displacement of tubes / Complications such as pressure ulcer/Injury rate and nosocomial infection rate / Number of resuscitation episode versus successful resuscitation rate

Psychosocial Indicators

Knowledge level / Satisfaction level /Number of complaints /Number of appreciations

General Indicators

Mortality rate / Length of stay / Unplanned readmission rate

Tracking of the above-mentioned psychosocial indicators and general indicators has been conducted at the hospital level. Data collection has focused on seven NSOIs which are grouped under three categories:

1) Adverse Incidents II) Complications III) Patient and patient's family satisfaction

I. Adverse Incidents:

1) Patient Falls 2) Displacement of tubes, lines and drains 3) Medication Error

II. Complications:

1) Pressure Ulcer/Injury
2) Nosocomial Infection (covered elsewhere in Chapter XX - Vollman)

III. Satisfaction: Patient and patient's family satisfaction on the quality of care received

We revisited the term "Nursing Sensitive Outcomes Indicators (NSOIs)"; studied the topic in depth; confirmed and defined the indicators to be reported; devised NSOI formulas for calculating rates; devised reporting forms to capture data; designed Training Need Analysis Tool and refined questionnaire for satisfaction survey (patient and family). Since early 2005, data on four NSOIs 1) Patient Falls, 2) Displacement of tubes, lines and drains, 3) Medication Errors and

4) Pressure Ulcer were captured in ICUs (at departmental/unit level) & reported on a six monthly basis. We aimed at capturing quality data for performance improvement and for presenting as a profile of ICU quality in the form of NSOIs because data collected can be used to compare among ICUs and to trend over time. Hospital acquired infection (nosocomial infection) data were collected by Infection Control Unit and satisfaction survey (patient / patient's family) satisfaction surveys were conducted at the hospital level.

Hence, an inventory of patient outcomes related to the scope of ICU nursing practice confirmed and data were collected at departmental level of all the public hospitals. Examples from this initiative are provided throughout this chapter to highlight the role of the critical care nurse in improving patient care in the ICU.

Acute Care Patient Fall

NSOI Definitions & Measurements

I. Adverse Incident

Acute Care Patient Fall

Definition:

The World Health Organization (2012) describes "Fall" as any unintentional event in which a person comes to rest on the floor. Lianne Jeffs et. al. (2005) defined acute care patient fall as the rate per 1000 patient days at which patients experience an unplanned descent to the floor during the course of ICU stay. All falls (accidental fall, unanticipated physiologic fall, and anticipated physiologic fall) should be reported and described by level of injury or no injury.

<u>The measure for the rate per 1,000 bed days occupied</u> at which patients experience unplanned descent to the floor during the course of their hospital stays would be computed as:

- **Numerator Statement**: Total number of patients falls leading to injury or no injury x1000

- **Denominator Statement**: Total number of patient days during the period (Total number of Bed Days Occupied)

Categorization of Falls

A patient fall is one of the major clinical risks in the health care setting. Patient falls have been recognized as a significant adverse event in hospitals. Falls can be categorized into 3 groups:

1. **Accidental fall** is caused by environmental or extrinsic hazards that could result in a trip or slip, which can be prevented by ensuring environmental safety.
2. **Anticipated physiologic fall** is associated with intrinsic factors such as aging, altered mental state, unsteady gait and sensory deficits, which can be prevented by specific interventions after assessment.
3. **Unanticipated physiologic fall** is attributed to unexpected physiologic events including fainting, orthostatic hypotension, seizures or the use of sedatives and hypnotics. Although this type of fall cannot be predicted before the first occurrence, subsequent fall is preventable (Morse, 2008). Therefore, patient fall is not an inevitable event; it can be prevented when appropriate prevention strategies are implemented.

In the hospital setting, a patient fall and fall-related injuries are associated with negative consequences on patients, relatives, as well as healthcare providers. Beyond physical injuries, patients may experience anxiety, loss of confidence and depression. Fall related physical injuries can lead to the escalation of hospital cost. The costs may be due to extra diagnostic test, treatment for injuries, rehabilitation, and extension of the length of hospitalization (Flanders et. al., 2009). Relatives may be anxious, leading to increased complaints and potential litigation. On the other hand, healthcare providers may also suffer from guilty feeling and shame on the failure of care (Patman et. al. 2011). Thus, patient falls must be addressed as one of the quality-safety indicators for healthcare institutions, and the ICU.

Data Reporting

Web-based electronic system can be employed to facilitate the timely reporting, analysis and recommendation. The following information can be included in the fall incident report:

1. Patient information, such as date of admission, diagnosis, and premorbid condition, such as conscious level and mobility.
2. Brief description of patient's action during fall and the reason behind, such as patient's cognitive and judgment problem, underlying medical condition, and patient's condition before fall was underestimated.
3. Immediate consequence such as pain, superficial injury & fracture.
4. Patient's condition after fall (nurse's assessment and observation).
5. Immediate management such as blood pressure checking, radiological investigation, dressing and inform relatives.

A set of comprehensive fall incident data are essential for conducting an effective root-cause-analysis (RCA).

Potential Fall Risks in Intensive Care Units

The etiology of a fall is multi-factorial. Commonly identified risk factors for in-hospital patient falls include:

1. Intrinsic Factors:

- Age (extremes of age: 1-5 or > 65 years of age)
- Falls history
- Syncope syndrome
- Continence problems
- Cognitive impairment

- Postural instability, mobility problems and / or balance problems
- Sensory impairment
- Medication such as cardiovascular drugs, drugs used in central nervous system, or poly-pharmacy
- Communication problems
- Health problems that may increase their risk of fall

2. Extrinsic Factors:

- Slippery floor
- Inadequate lighting
- Inappropriate height of beds and chairs
- Trailing electric cords
- Not fitting slippers

(Source: Hong Kong East Cluster, Hospital Authority, Hong Kong: Quality and Safety Office, 2014 & Queen Mary Hospital: Patient Safety Subcommittee, 2012)

However, the etiologies of fall in critically ill patients are specific. The intrinsic factors of the falls in ICU include de-conditioning of patients, which can occur rapidly after ICU admission. Extrinsic factors are related to the fall, which are less with slippery floor or lighting but more with the amount of tubes, cables, or drainage bags attached to patients. The equipment hinders patient's mobility as well as increases their risk of falls. The uniqueness of fall risk factors in the ICU generates unique preventive measures (Patman et. al., 2011).

Cases Sharing with Learning Points

One fall incident happened in Tuen Mun Hospital when patient was sat out in chair with no railing and there existed just a mobile bedside table nearby. The patient felt tired, and attempted to return to bed by himself without notifying nurses. With unsteady gait, he eventually fell on the floor. After this incident, a **"sit out checklist"** was developed to ensure that safety measures had been taken before we sat the patient out of bed (Appendix 1).

Furthermore, fall incidents usually happened during meal time or during the time when nursing manpower is thin (duty staffs are overloaded with work or being occupied by other patients). Sometimes, inattention or less vigilance of staffs is a risk factor for falls in ICUs. Hence, having **safety rounds** by designated patrol nurses at regular intervals and during peak hours is highly recommended.

According to the sharing among NSOI sub-committee members, certain brands of split type side rails had been identified as a potential risk item. They did not cover the full length of the bed; patient could easily get out of bed by moving to the end of it. It was proven by one reported incident. NSOI subcommittee members were advised not to purchase that brand of side rails. Nurse executives were recommended to pay more attention to the **choice of bed** in the future.

Moreover, NSOI subcommittee members also identified that a negative pressure isolation room had the potential risk for fall. **Isolation rooms** provided a physical barrier and delayed nursing actions. If a nurse noted a dangerous action of patient inside the room, she/he might not be able to approach the patient in time. The need for putting personal protective equipment on before entering the isolation room delayed nurses' responses. Although no fall incidents inside the isolation room was reported, the risk of fall would be anticipated. Critical care nurses should be on the alert for this potential risk and perform frequent patient rounds when patents are being cared for in the isolation rooms. Overall, critical care nurses are required to identify the unique risk factors for each individual patient and implement timely interventions whenever necessary.

Fall Prevention Strategies

To prevent falls, an integrated multi-factorial approach is recommended as follows:

1. Identify high risk patient through assessment

2. Implement interventions to minimize risk of falls
3. Monitor the fall rates
4. Provide education

The Morse Fall Scale (MFS) is an individualized criterion-referenced assessment tool which is designed for measuring the likelihood of adult patient falls in hospitals. There are a few assessment tools available which are specific to ICUs' setting e.g. St. Thomas's Risk Assessment Tool in Falling Elderly in Patients (STRATIFY); Downton fall risk tool; Tullamore tool; and Tinetti fall risk index. Most ICUs in Hong Kong adopt **"MFS"** as their fall risk assessment tool. It consists of six variables that are quick and easy to be scored, namely 1) history of falling, 2) secondary diagnosis, 3) the use of ambulatory aids, 4) intravenous therapy/intravenous assessment, 5) gait condition, and 6) mental status. Each variable is scored from 0 to 30 marks. If the score is less than 45 marks, the risk level will be defined as "not at risk". If the score is equal to 45 marks or more, the risk level will be defined as "high". Risk assessment should be done on admission, then to be repeated on regular interval and whenever condition warrants (i.e. change of health status or after a fall incident).

In fact, most of the ICU patient scores are high when using "MFS". The sensitivity of the tool to differentiate the high risk group patients may not be absolutely adequate in critical care setting, so clinical observation and clinical judgment are indispensable in assessing fall risks of ICU patients. Developing new fall risk assessment tool on the uniqueness of critically ill patients should be considered by the critical care nurse to meet their patient care needs as indicated (Flanders et. al., 2009).

Interventions (Universal or Specific) to Minimize Fall Risks

Two levels of preventive measures could be implemented to target fall prevention. Universal fall prevention interventions should be offered to all patients. In addition, specific interventions for high risk groups after professional judgment should be implemented.

1. Universal fall prevention interventions include:

- Orientate patient to ICU environment and routines
- Provide call bell in reach and educate the using of call bell system
- Respond to patient's call as soon as possible
- Keep the necessary items / frequently used belongings within reach of patient
- Stabilize the bed, sit out chair and bed rail with brakes locked etc.
- Ensure the patient's clothing and footwear are properly fitted when assist the patient to walk about, e.g. roll up the pants to prevent tripping.
- Advice patient to put on appropriate spectacle or hearing aid to improve communication
- Provide pamphlet on falls prevention to patient and relative

2. Specific Interventions for high risk group include:

- Make fall risks as part of nurse-to-nurse report (both at shift change and meal break).
- Display fall hazard signage on patient's head of bed for better communication between all healthcare providers
- Relocate agitated patients to easy-observable bed
- Provide constant inspection / ward round by patrol during peak hour such as meal time and admission of emergency cases
- Provide regular assistance for toileting to patients as required
- Educate the patient about his/her risks to fall periodically
- Inform relatives that the patient is at high falls risk
- Manage delirium & postural hypotension
- Optimize falls related medication such as psychoactive and cardiovascular drugs
- Use restraints as last resort and review periodically
- Address identified falls risk to general ward staff when discharge from ICU

(Source: Kowloon Central Cluster, Hospital Authority, Hong Kong: Task Group on Patient Falls, 2014; Hong Kong East Cluster: Quality & Safety Office, 2014; New Territories West Cluster: Clinical Service/Chairperson of Cluster Clinical Governance Committee, 2014; Queen Mary Hospital: Patient Safety Subcommittee, 2010)

Physical Restraints

Physical restraints should be used as a last resort since it can be both humiliating and harmful. Critical care nurses should follow hospital guidelines on applying physical restraints on patients and providing appropriate observation and care to the restrained patients.

The value of applying physical restraints in ICU should be evaluated regularly. As an example, in 2012, Tuen Mun Hospital ICU implemented a quality improvement program on “Application of Physical Restraints”. The aims of this program were to minimize the inappropriate use of physical restraint, and ensure patients’ dignity and safety. A scoring tool was established to provide an objective guide for nurses when applying physical restraint. The scoring tool included patient’s behavior and muscle power, the types of medical devices/ equipment that the patient had as well as special considerations. Patients are categorized under three color zone according to the total score – Red, Yellow and Green. Red zone – restraint should be considered as necessary for the best interest of patients; Yellow zone - decision of using physical restraint is subjected to nurses’ judgment; and Green zone – restraint should not be applied (Appendix 2). Electronic calculation of restraint score has been installed in the Clinical Information System of the hospital to facilitate the implementation. Signage is hung on each bed as a reminder. A clinical audit on the use of the scoring tool was conducted from September 2012 to December 2012. Compliance rates of using the scoring tool and inappropriateness of using restraint were evaluated.

A total of 555 ICU patient episodes were involved in the evaluation. The compliance rate of using the scoring tool was 80%. Approximately, 40% of patients were physically restrained at the time of audit; the prevalence rate was similar to the background rate which was 35% according to the prevalence study. Inappropriateness was much improved, decreasing from

12% to 5% of patient episodes after the project was implemented. A total of 40% of patient episodes were not restrained as they were categorized under the Yellow zone. The objective scoring system was considered useful to minimize the inappropriate use of physical restraint in ICUs, and it provided autonomy for nurses to make restraint decision. Validation of this scoring system would be considered in our next step of ward improvement action.

As a result of the initiative, the ICU will take the initiative to start a quality improvement project on "Reduction of Physical Restrainer Rate". The project will be led by nurse consultants. Subsequent to data collection, analysis and benchmarking will also be performed. We hope that this project could improve appropriate use of physical restraints in the ICU.

Fall Rate Monitoring and Staff Education

Ward managers are delegated to report, monitor, analyze the trends, and review the preventive measures periodically (Queen Mary Hospital: Patient Safety Subcommittee, 2010). Education on falls prevention and management are provided for new staff. It should be included in the preceptorship program and refresher program. All staff should be trained with skills to depict reversible risk factors, identify potential fallers and implement appropriate interventions. In addition, attractive data display boards are recommended to increase staffs' awareness. Fall debriefings should be conducted after each fall incident. It is non-punitive, and it is a chance for learning and improvement (New Territories West Cluster: Clinical Service/Chairperson of Cluster Clinical Governance Committee, 2014). Staff engagement in fall investigation and sharing the recommendations with staff are successful elements on fall prevention management.

APPENDIX 1: Tuen Mun Hospital ICU Checklist for Sitting Patient Out of Bed

HOSPITAL AUTHORITY TUEN MUN HOSPITAL ICU CHECKLIST FOR SIT OUT	ADDRESSOGRAPH

* Please read before and sign after the sit out procedure by case in-charge nurse.

Yes =√, No= X, NA= Not Applicable

No.	Behaviors	Yes/No/NA	Remarks
1.	Assess patient general condition whether he/she is fit for sit out with agreement of physician.		
2.	Adjust bed in the lower position and brakes locked, so that it is safer for the patient to sit on and sit out of bed.		
3.	Educate the patient to move slowly from a lying to a sitting or standing position to minimize dizziness and falls due to postural hypotension.		
4.	Provide appropriate and adequate assistance for transfer.		
5.	Accommodate the patient near the bed and within eye reach of nurses for more easy observation and detection of risk.		
6.	Ensure the wheels of sit out chair are locked.		
7.	Ensure all IV lines, drains & catheters in proper position and secure well.		
8.	Educate the patient to stay in chair until helper arrives.		
9.	Observe the patient vital sign and stay with the patient until condition stable.		
10.	Reinforce calling for assistance.		
11.	Arrange patient's belongings and call bell within reach.		
12	Provide scope for divisional activities.		
13.	Re-orientate patient frequently.		
14.	Educate patient not to climb out of chair or ambulate alone.		
15.	Respond to patient's need promptly.		
16.	Invite relatives to stay with the patient if needed, especially for dementia and confused patient.		
17.	Apply safety vests and/or limb holder if necessary.		
	For safety vest and/ or limb holder(s) applied:		
18.	Ensure the safety vest and/or limb holders in proper position and functioning well.		
19.	Explain the need of restraint to patient and gain his/her co-operation.		
20.	Perform close observation for patient after apply restraint equipment & document promptly.		
21.	Inform physician the reasons of restraint.		
22	Inform relatives/significant others as soon as possible.		

Name of nurse:_______________ Signature:_____________ Date:_____________ Time:_______________

APPENDIX 2: The Grading and Scoring System for Applying Restraint in ICU, Tuen Mun Hospital, Hong Kong

The Grading and Scoring System for Applying Restraint

Code Green (not suggest to apply restraint)

When: Score <8

Code Yellow (subject to nurse's decision, apply restraint for the best interest of patient care)

When: Score between 8-16

Suggested action:

1. Physical restraint suggested
   Score 8-12 try mitten (with rod/without rod) +/-safety vest
   Score 13-16 try limb holder + mitten (with rod/without rod) +/-safety vest

2. Exclude reversible cause
   a Foley obstruction
   b Bowel opening
   c Check GEM for Na, O2, CO2 & H'stix
   d Pain assessment
   e Inform MO if needed

3. Consider to use communication board

4. Consider to off restraint intermittently if condition feasible

Code Red (Strongly suggest to apply restraint until MO/AC assessment)

When Score>16

Suggested action
Limb holder mitten+/-safety vest
Exclude reversible cause similar as above

A. Behavioral level

1. Unconscious/semiconscious +0
2. Alert and calm +0
3. Restless or agitated +4
4. Combative +8
5. Currently or previously try to remove devices +8

B. Life Sustaining Device

1. Mechanical ventilation/BIPAP +2
2. Tracheostomy tube +1
3. Central line/ A-line / peripheral IV assess +1
4. Chest/pigtail/surgical drain/IABP/IV pacing +2
5. ICP +2
6. Supra-pubic catheter +2
7. CVVH/Dialysis +2

C. Muscle Power level

1. No or only visible sign of muscle contraction only +0
2. Insufficient muscle power to overcome gravity +2
3. Sufficient muscle power to overcome gravity +4
4. Full muscle power +6

D. Other Conditions

1. In Isolation room. +8
2. Difficult Airway. +8
3. When sedation withhold for conscious state assessment or extubation. +8

Prepared by Dr H M Lee
Version VI Date: 12 July 2012

<u>Displacement of tubes (Endotracheal/Tracheostomy, i.e. Unintended extubation), lines and drains</u>

<u>Definition</u>

An unintended incident during which the appropriate marking on the tube inserted is found to be different from the previous observation or previous record, and the primary function of the tube cannot be achieved.

<u>The measure for the rate per 1,000 bed days occupied</u> would be computed as:

- **Numerator Statement:** Total number of confirmed unintentional displacement of tubes/lines/drains x1000
- **Denominator Statement**: Total number of patient days (Bed Days Occupied) within the period

Country Specific Exemplar Focusing on Decreasing Displacement of tubes (Endotracheal/Tracheostomy, i.e. Unintended extubation), lines and drains.

The majority of the ICUs in Hong Kong are within the public sector. There exists an electronic self-reporting system for reporting incidents in all public hospitals in Hong Kong. In view of the uniqueness of each ICU, the incident rate may not truly reflect the performance of individual hospitals. However, the result thus generated from 13 Adult ICUs still can serve as a reference when we compare the trend of performance of individual hospital and the aggregated numbers of all hospitals. Basing on the analysis, contributing factors and correlating factors are mapped out and comments and recommendations are summarized for quality improvement purposes.

Content of the Reporting Form

The self-reporting form (Appendix 1) includes patient's personal particulars; date and time of incident; personnel involved regarding the displacement; description of incident; details about the displaced tube/line/drain; factors contributing to incident; patient outcome; and evaluation.

Background information of the incident includes incident occurred during shift handover or meal break, and/or when patient undergoing nursing procedures like bed bathing, position turning, ambulatory activities, admission and discharge activities, or transportation, medical procedures or other procedures, or when case nurse being occupied by care of another patient, preparation of works or ward round. Patient factors include whether the patient received sedation, was restless, any communication problems, being physically restrained (secured or loosen), and level of cooperation.

The report also includes system and human factors that contribute to the incident. For the system factors, the nurse could select one or more items including poor design or maintenance of device, poor quality of material, poorly secured tube/drain/line, high activity level, below normal staff and patient ratio, inadequate staff training, and inconvenient patient location including those in the side or isolation room. For the human factors, the nurse could choose inadequate patient assessment, incompetent in or unfamiliar with unit protocol or guidelines, distraction, or inattention.

The patient outcome also needs to be reported if the displaced tube/line/drain will require reinsertion and/or re-intubation within 24 hours.

The case nurse also evaluates whether the incident is avoidable or unavoidable and recommends any improvement initiatives to avoid the incident happening again. The self-report is reviewed by a shift in-charge or senior nurse to check whether the input data are accurate or not.

Summary of Data

Data were collected from 13 hospitals and analyzed for the period from January 2010 through December 2013.

Table 1: Patient days across all the 13 Adult ICUs

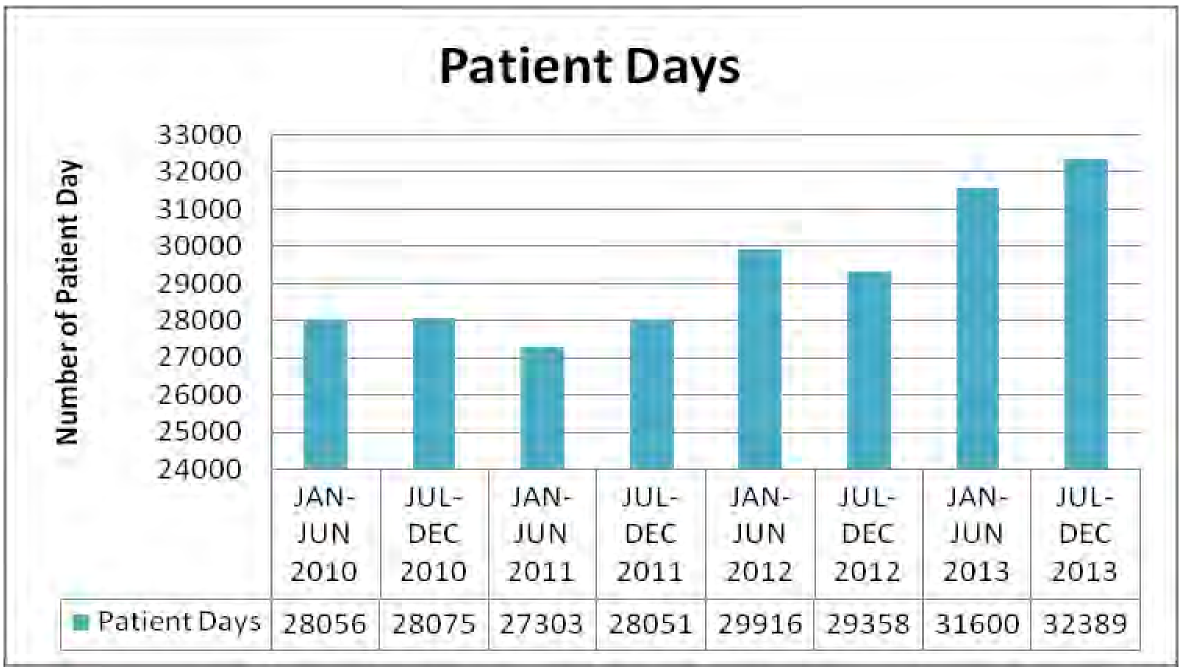


Table 2: Number of dsiplacements across all the 13 Adult ICUs

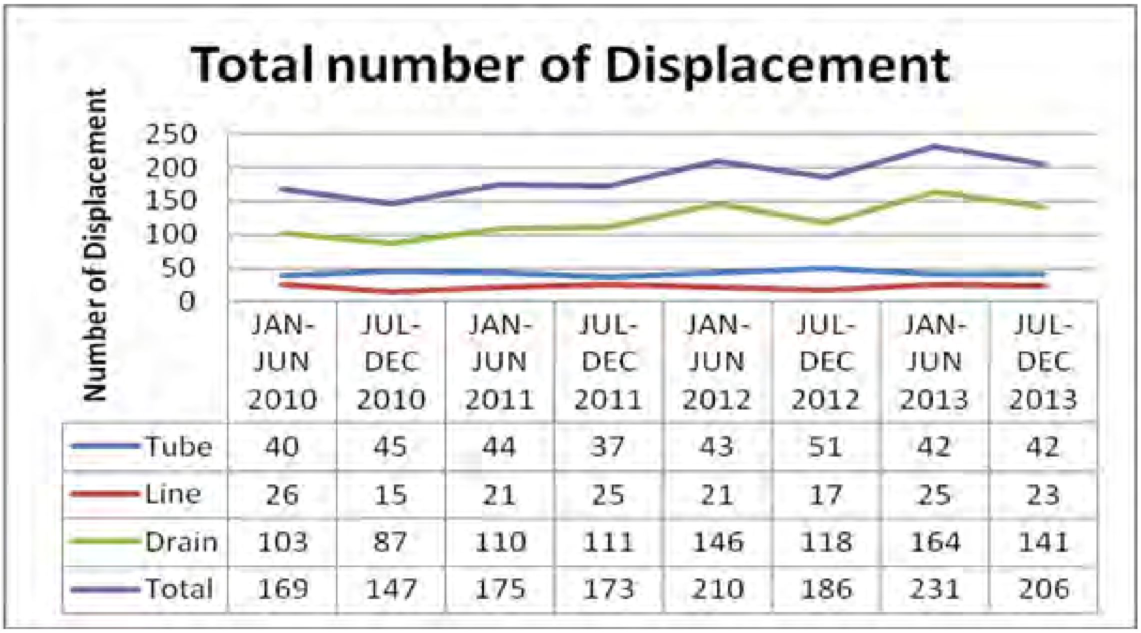
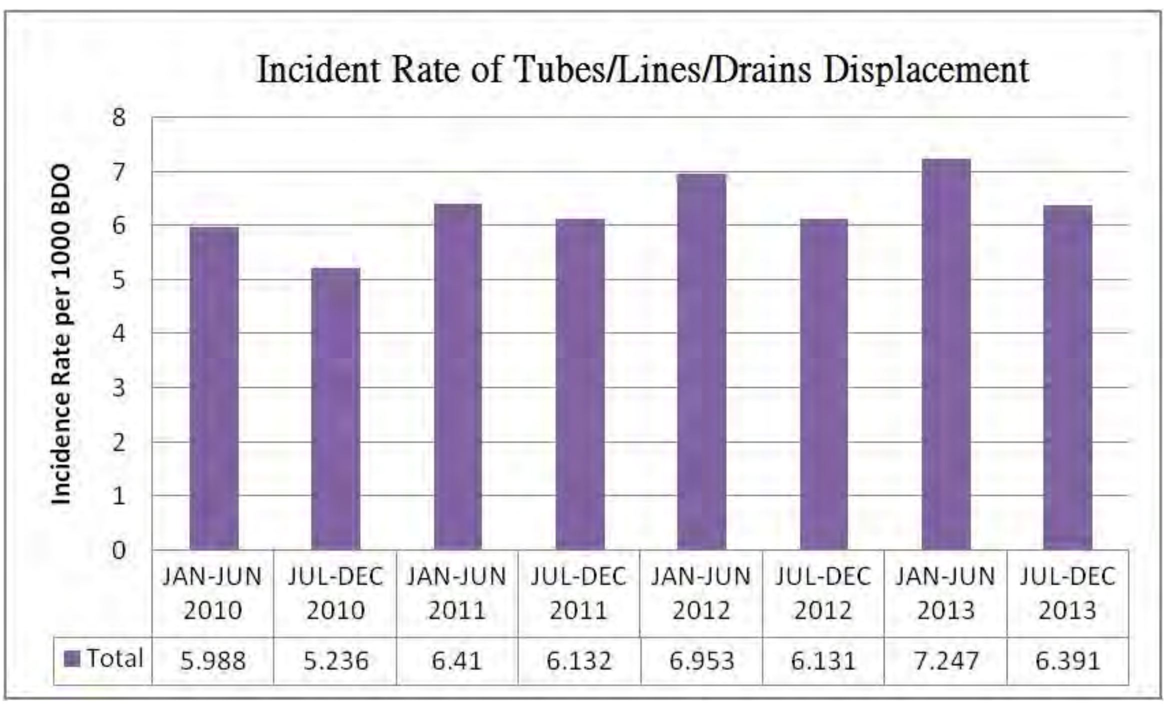
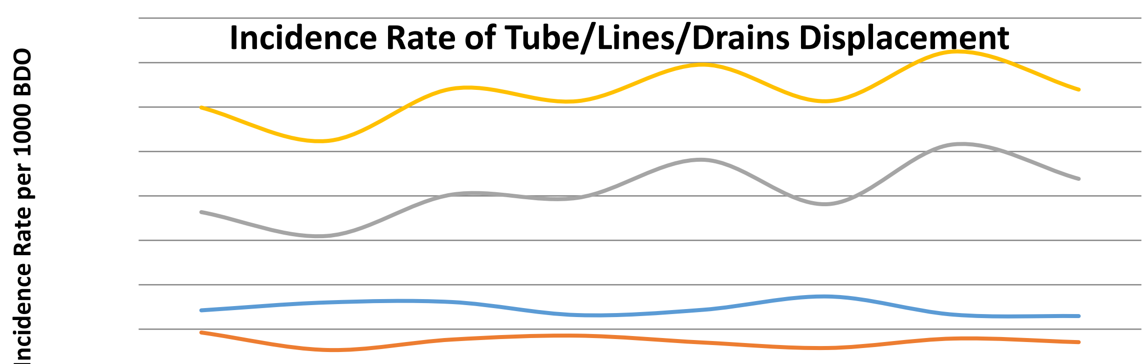


Table 3: Displacements per 1000 bed days across all the 13 Adult ICUs



The overall patient days (PD) increased from 28,075 (2010) to 32,389 (2013) (Table 1). The total number of displacement slightly increased from 169 to 206 incidents (Table 2). The total displacement incidents also slightly increased from 5.988 in the first half year of 2010 (Table 3). to 6.391. Compared 27303 (PD) in January - June 2011 with 32389 (PD) in July - December 2013, the incident rate of displacement was slightly decreased from 6.41 to 6.391, in contrast with the (PD), there was an increase of 13.3%.

Table 4: Breakdown of displacement incident rate by tube type.



	JAN-JUN 2010	JUL-DEC 2010	JAN-JUN 2011	JUL-DEC 2011	JAN-JUN 2012	JUL-DEC 2012	JAN-JUN 2013	JUL-DEC 2013
ET/TT	1.426	1.603	1.612	1.319	1.437	1.737	1.329	1.297
Line	0.927	0.534	0.769	0.856	0.702	0.579	0.791	0.710
Drain	3.636	3.099	4.029	3.957	4.813	3.815	5.158	4.384
Total	5.988	5.236	6.41	6.132	6.953	6.131	7.247	6.391

However, the total number of displacement had slightly increased especially on drains and the rest remained the same throughout the reviewed period (Table 4).

Displacement of endotracheal tube (ETT) and tracheostomy tube (TT) may have serious life threatening outcomes. It is observed that patients usually received less, or even no, sedation during weaning which further increases their discomfort when they have to cope with their physiological stress of the weaning process. The nursing strategies may be, a) promoting patient comfort during intubation, b) better communication between nurse and patient, and c) nurses staying at the bed-side to decrease the risk of self-extubation.

Displacement of central venous catheter (CVC) and renal replacement vascular accesses (Haemodialysis Catheter) might cause interruption of life saving therapies. Most of the causes were related to inadequate anchoring of the catheter, e.g. the CVC inserted in operation theatre had frequently no anchoring stitches applied. Therefore, the catheter would easily displace or dislodge. There was no data on displacement of pulmonary artery catheter (PA catheter) after 2010 which might be related to the preference of using echocardiogram to monitor the hemodynamic status of patients rather than using PA catheter. Avoidance of vascular line displacement remains an important focus to address, in particular about the practice of securing the catheters.

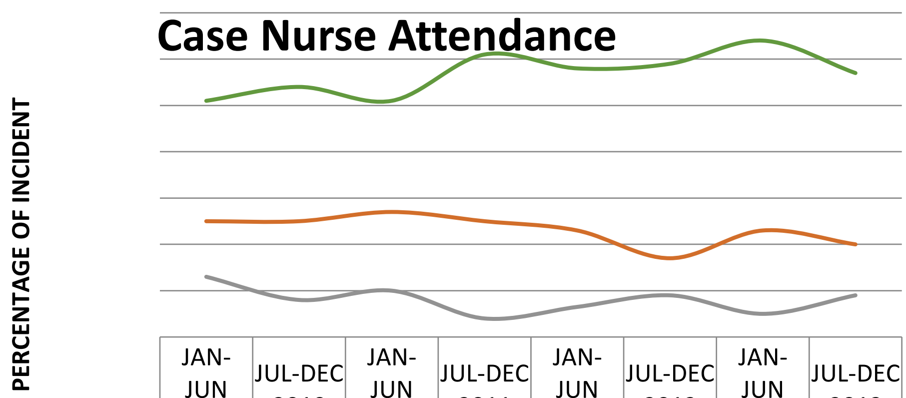
Displacement of nasogastric tube (NG) for feeding accounted for high percentages in several reports. NG tube is the most commonly used tube being inserted in ICUs. Usually no anchoring stitch is applied and patients may easily pull it out. Although no life threatening incident that was due to NG feeding tube displacement was recorded, the displacement could contribute to higher risk of aspiration, and the repeated insertions could cause discomfort and injury to patient. It is highly recommended to make an extra effort in securing the NG tube, especially when it serves as a drain and is placed intra-operatively. On the other hand, the displacement of thoracic drains may cause potential fatal outcomes such as tension pneumothorax. Therefore, it is highly recommended that individual hospitals should pay attention to the rising trend and focus on prevention of these incidents (Table 7).

In our experience most of the tube displacements happened during night shifts. However, when the length of shift was taken into account, the incident rate during night shift was nearly the same as day time. While the nurse: patient ratio for night shifts was less in most hospitals in the public system, it was recommended that nurses should make extra efforts to maintain the quality of care during night shifts.

Analysis of Incidents

The top three environmental factors contributing to occurrence of incidents (Table 5) were when nurses were occupied with providing care to other patients, during meal / tea break and during nursing procedures. This implied that patients being less attended to or unattended had a higher risk of displacement of tube/line/drain. These reasons appear to be related to the nurse: patient ratio during night shifts.

Table 5: Tube displacement correlation with other activities occupying nurse's attention.



	JAN-JUN 2010	JUL-DEC 2010	JAN-JUN 2011	JUL-DEC 2011	JAN-JUN 2012	JUL-DEC 2012	JAN-JUN 2013	JUL-DEC 2013
MEAL BREAK	25%	25%	27%	25%	23%	17%	23%	20%
Nursing Procedure on Same Patient	13%	8%	10%	4%	6.50%	9%	5%	9%
NURSE BEING OCCUPIED by other Patient	51%	54%	51%	61%	58%	59%	64%	57%

The presence of the ICU nurse was a crucial factor in prevention of tube displacement incidents. It would be necessary to adjust the manpower arrangement during meal time or tea breaks because it was found that during shift hand-over and meal/tea break, patients were prone to have tube/line/drain displacement. In addition, arrangement of work to perform non-urgent labour intensive activities should be done only when there was adequate manpower. Around 8% of tube/line/drain displacement incidents occurred during nursing procedures. It is recommended that nurses should be more alert to maintain all tubes, lines and drains during procedures to prevent displacement. Assigning staff as patrol nurses to perform patient safety rounds would be recommended especially during high risk period.

Factors Contributing to the Incidents

Patient Factors - The presence of tube, line and drain might cause great discomfort to patients. Nursing measures were implemented to minimize patient's discomfort including nurse reassurance, effective communication, and appropriate use of physical restraint. There were many cases when physical restraints were applied and periodic reviews on the effectiveness of restraint were needed. As mentioned earlier in this report, patients with minimal or no sedation during weaning stage were running the risk of having tube/line/drain displacement incident(s). Effective communication between doctors, nurses and the healthcare team members is essential to ensure a balance between appropriate sedation and prevention of displacement incidents.

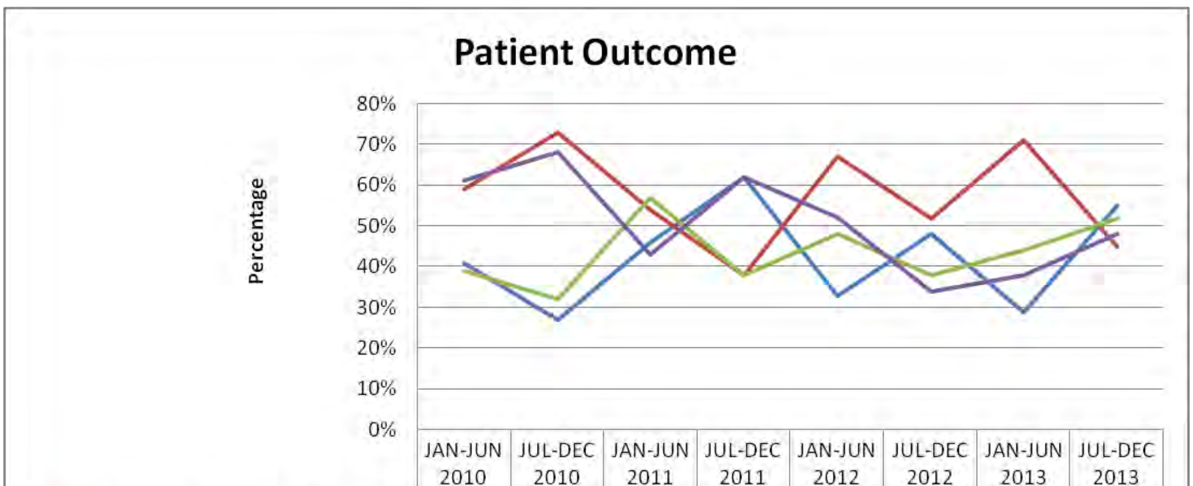
System Factors - The commonest cause of displacement incidents was due to high activity levels. This implied that nurses were occupied by various activities and attention to certain patients could have been diverted.. Poorly secured tube/line/drain was the second commonest system factor contributing to displacement incidents. Individual ICUs should continue to work out the best methods to avoid incidents. Patient's in isolation rooms was the third common system factor. Nevertheless with the increase in awareness of infection control measures, there might be more patients requiring isolation. It was recommended that nurses should be more alert to patients located in isolation rooms.

Human Factors – Incidents occurred and were possibly related to not addressing a patient care need. For example, one patient complained about the discomfort with the nasal gastric tube and the nurse should have attended to him immediately. Nurses should remind other healthcare professionals about the presence of drains and tubes when the patient has to undergo bedside procedures. Frequent observation and continuous assessment should always be maintained.

Patient Outcomes

Artificial airway is a very important life saving device for ICU patients. Among those displacement of ETT and TT, **an average of 43% of the related patients required re-intubation.** Individual ICUs should pay special attention to their own incidents and implement appropriate preventive measures to prevent tube displacement. Findings from January 2010 to December 2013 (Table 6) showed no significant differences in the requirement of reinsertion of line or drain after displacement.

Table 6: Reintubation (ETT) and reinsertion (TT) rates in source ICUs



	JAN-JUN 2010	JUL-DEC 2010	JAN-JUN 2011	JUL-DEC 2011	JAN-JUN 2012	JUL-DEC 2012	JAN-JUN 2013	JUL-DEC 2013
REINTUBATION WITHIN 24 HOURS	41%	27%	46%	62%	33%	48%	29%	55%
NOT REQUIRED REINTUBATE	59%	73%	54%	38%	67%	52%	71%	45%
REINSERTION WITHIN 24 HOURS	39%	32%	57%	38%	48%	38%	44%	52%
NOT REQUIRED REINSERTION	61%	68%	43%	62%	52%	34%	38%	48%

Conclusion

The overall ICU displacement incidents were similar in contrast with the increasing bed days occupied, which reflected that the current measures in preventing displacement incidents among various hospitals were effective. It requires a multi-disciplinary approach in preventing displacement incidents. Effective communication among doctors, nurses and health care assistants is essential. Identifying patients at risk, time at risk can help to initiate proactive measures to prevent line/tube displacement.

Recommendations

It was found that the types of tube displacement with high incidence rates over the period of four years (2010 to 2013) were endotracheal tubes and nasogastric tubes. Frequent reminders and explanation to patients about the importance of the tubes could help to prevent self-extubation. Staff should be on the alert for restless and uncooperative patients during duty handover. Before leaving the at-risk patients, nurses should ensure that all life supporting devices are properly secured and, if necessary make arrangement for supporting staff to actively monitor patients.

Appropriate staff deployment could minimize the occurrence of incidents. Nurses should be encouraged to call for help when they are expected to be occupied for a long period of time. Reassurance and promotion of comfort could help to gain the cooperation from patients. Senior nurses should remind staff to hold tubes, lines and drains carefully and stay alert when they are repositioning patients and/or equipment.

Reviewing major incidents, especially the avoidable cases, could raise staff awareness. Posting of the incident numbers and trends in the working area can remind and enhance staff alertness. Heightened staff awareness coupled with caring attitude is essential to minimizing displacement incidents.

The Way Forward

It is proposed to enhance communication between doctors and nurses during weaning stages for sedation control, and the appropriate time for extubation. With an aim to shorten patient's length of stay in ICU, trials on nurse initiated extubation in weaning patients from ventilators may be able to minimize displacement incidents. Furthermore, proper use of sedation scoring scales could minimize patients' discomfort. Periodic patient safety rounds are a pro-active measure to identify patients at risk of incidental displacement so that prompt preventive measures can be implemented. Briefing and debriefing on post displacement incidents are encouraged so as to have the cases reviewed and good practices shared in order to achieve better patient outcomes. Near-displaced incidents should be mentioned to colleagues to prevent displacement to happen on the same patients again. It is invaluable to continue having this self-reporting system of displacement incidents with a blame-free or no blame culture.

Appendix 1

(Name of Institution) Tube/ Line/ Drain Incident Reporting form	**Patient Gum Label** **or** **Patient HN:________________________**

Definition of Displacement of tube/ line/ drain:

It is an unintended event. The appropriate location or marking of tube / drain is found to be different from the previous observation or record, and its primary function cannot be achieved.

Date of incident: ______________________________ Time:____________________(AM / PM / N shift)

Displaced by:☐ patient ☐ nurse ☐ doctor ☐ unknown ☐ supporting staff ☐ others: __________

Description of incident:

Displacement of tubes :	***Displacement of central lines:***	***Displacement of drains*** :
Been inserted for _____ days ☐ Endotracheal tube ☐ Tracheostomy tube ***Displacement of Nasal GastricTube*** : Been inserted for _____ days For ☐ Feedings ☐ Drainage	Been inserted for _____ days Site: ____ ☐ Central venous catheter ☐ Pulmonary artery catheter ☐ Renal replacement access line ☐ Other: __________________________	Been inserted for _____ days ☐ Head drain ☐ Thoracic drain ☐ Abdominal drain ☐ Urinary catheter ☐ Mediastinal drain ☐ Other: __________________________

Incident Background

Factors contributing to incident (can tick more than 1box if appropriate)

Incident occurred during : (please tick box(es) and circle either one factor) ☐ Shift handover / meal or tea break / night food break Patient undergone ☐ ***Nursing procedures*** : bed bath / ambulation / admission / discharge / transportation__________ ☐ ***Medical procedures***:______________________ ☐ ***Other procedures:***_______________________ ☐ Case nurse occupied by: other patient care / preparation works / ward round / ☐ Others : ____	***Patient factor : (can tick more than 1 box)*** Sedation: ☐ Yes ☐ No Restless: ☐ Yes ☐ No Communication problem: ☐ Yes ☐ No Physical restraint:: ☐ Yes secured / loosen ☐ No Cooperation: ☐ Yes ☐ No ☐ Others: _______________________________________
System factors: ☐ Poor design/ maintenance of equipment : ____ ☐ Poor quality of material: ____ ☐ Tube / drain / line poorly secured ☐ High activity level ☐ Below normal staff and patient ratio * ☐ Inadequate protocol	**Human factors:** ☐ Inadequate patient assessment ☐ Inadequate competent ☐ Unfamiliar with unit protocol / guideline ☐ Distraction / Inattention ☐ Other: ______________

☐ Inadequate training ☐ Inconvenient patient allocation: Side/Isolation room ☐ Other : ________________________________	

- * Subject to individual hospital's ICU/HDU bed nature
- * During night shift / meal break, staff patient ratio is half of that of day shift and regarded as normal

Patient Outcome:

☐ Reinsertion of line and drain is required within 24 hours ☐ Reintubation is required within 24 hours	☐ Reinsertion of line and drain is not required ☐ Reintubation is not required

Evaluation:

The incident is : ☐ Unavoidable ☐ Avoidable Improvement initiatives:

Reported by:

Rank:__________ Name:_________________ Signed:________________ Date: ______________

Reviewed by:

Rank:__________ Name:_________________ Signed:________________ Date: ______________

Thank you for your reporting!

This report is used for data analysis. We aim to recommend solutions to prevent further displacement incidents.

MEDICATION ERRORS IN THE ICU

Medication Error (ME) & Medication Incident (MI)

The National Coordinating Council for Medication Error Reporting and Prevention (2009) defined a medication error as "any preventable event that may cause or lead to inappropriate medication use or patient harm while the medication is in the control of health care professional, patient, or consumer. Such events may be related to professional practice, health care products, procedures, and systems." Another extensive review of medication safety in the ICU by Kane-Gill et al. (2006) defined medication errors as "preventable mistakes or a deviation in planned action."

Medication errors are major issues in the health care setting and particularly prevalent in highly technical specialty areas such as the ICU.

Medication Incident (MI) which stresses the quality processes of the drug administration, is now used in modern literature. Medication incidents include errors in prescribing, dispensing and drug administrations. The incidents may be patient involved or non-patient-involved.

The measure for the rate per 1,000 bed days occupied would be computed as:

Numerator Statement: Total Number of medication incident occurred x1000

Denominator Statement: Total number of patient days during the period (Total number of Bed Days Occupied)

MEDICATION INCIDENTS IN ICU

Critically ill patients receive nearly twice as many medications as patients in general care units, and as a result, are at risk for a potentially life-threatening error during their hospital stay (Eric 2008). Reviews have estimated that patients in the ICU can encounter on average 1.7 errors per day, with nearly 50% of all ICU adverse events being medication related (Donchin 1995 & Rothschild 2005).

Patients in the ICU are at higher risk for adverse drug events for many reasons. These include illness severity, complexity of care, frequent use of complex drug regimens, high-alert medications, and the need for frequent drug dosing. Additionally, the busy environment, heavy workload and frequent stressful situation for the staff can predispose the ICU setting to having a greater incidence of medication errors (Vos 2007).

Data Reporting

Medication errors (MEs) in ICU can place patients at risk of injury or death. It is essential to minimize and prevent the incidence of MEs, hence offering the best protection to our patients. A comprehensive data collection system with the aim to establish a database on medication errors which includes all error reports related to medication use in the prescribing, administration, dispensing and preparation is needed.

Some hospitals use the Advanced Incident Reporting System (AIRS) to report medication incidents. AIRS is a web-based electronic system serving as a tool to support risk management by facilitating the reporting, classification, analysis, management of incidents and marking improvement.

The report includes the following information: patient information, the location and time of the incident, a description of what happened and what was done about it, the condition of the patient, the event outcome, severity index describing patient outcomes following medication errors as in **Table 1 & 2** and any additional information required by the facility policy. A comprehensive medication incident form is essential for the data collection and for root causes analysis to evaluate the factors and prevention measures for improvement in medical safety as the sample **Form 1.**

Form 1 - Medication Incident Report Form

Date: _____/_____/______ Duty Shift: □ A □ P □ N

Case Nurse:					
Error Identified by:					
Residents(s) involved:					
Type of Errors (circle all that apply)	1. Prescribing	• Wrong Drug • Wrong Dosage form • Wrong Strength/dosage • Wrong Duration • Wrong Frequency • Wrong Route		• Wrong Abbreviation • Wrong Instruction • Wrong Patient • Double Entry • Drug Omission • Known Drug Allergy	
	2. Dispensing	• Wrong Drug • Wrong Dosage Form • Wrong Strength/dosage • Wrong Quantity • Known Drug Allergy		• Wrong Patient • Wrong Label information • Double Dispensing • Drug Omission	
	3. Administration	• Wrong Drug • Wrong Dosage Form • Wrong Dose • Wrong Flow Rate • Wrong Patient • Wrong Route/methods		• Wrong IV diluent • Wrong Time • Extra Dose • Dose Omission • Unordered Drug • Known Drug Allergy	
When did this occur?	Date/s:			Time/s:	
When was the incident identified?	Date/s:			Time/s:	
Describe the medication					

incident of error:			
Possible reason(s) for incident:			
Immediate action taken:			
Reported By:		Signed:	

Supervisor notified (Name/ Rank):	□Yes □No	Date/Time:
Doctor notified (Name/ Rank):	□Yes □No	Date/Time:
Pharmacist notified	□Yes □No	Date/Time:
Next of Kin notified:	□Yes □No	Date/Time:
Treatment ordered by Doctor/ Pharmacist (Name/Rank):		

Support Worker/ Coordinator to Complete – Incident Analysis

Category of Incident:

□ Incorrect client

□ Incorrect medicine

□ Incorrect dose

□ Incorrect time

□ Incorrect route

□ Split or dropped medicine

□ Out of date medicine

□ Missing medicine

□ Lack of documentation such as assessment, medication order, medication support plan, medication record sheet(if required)

□ Request by a client/care to not give medication

□ Breach of the Organization policy and guidelines

□ Client refuses medication

□ Incorrect storage of medications

□ Incorrect supply of medications from the pharmacy

□ Other (describe) ________________________________

____

____

Coordinator to complete—Incident Analysis Conclusions

What, if anything could have prevented the incident?

Describe:

____

Was the incident related to a procedure breakdown (staffs focus)? □ Yes □ No

Comment:

____

Was the incident related to the medication management system

(Prescription, supply, documentation focus)? □ Yes □ No

Comment:

____

Was the immediate action taken appropriate? ☐ Yes ☐ No

Comment:

____

Coordinator to Complete – Action Plan (Insert further actions as required)	Who	by When	Date Completed
Analysis completed			
Follow up with staff member/s			

Coordinator to Complete – Closure

Evaluation (If appropriate, describe how action/ improvements were evaluated and the result):

____

____

____

Outcome or end result: (Tick applicable boxes)

□ Issue resolved – no improvements implemented

□ Improvement implemented

(describe) :____

Closed Out/ Complete:

Coordinator's Signature: __________________________ Date:

____

CLASSIFICATION OF PATIENT INJURY AND MANAGEMENT

Table 1 Classification of patient injury (Severity Index = SI)

SI = 0 Incident occurred but	SI = 1 Incident occurred (reached patient) but	SI = 2 Minor Injury	SI = 3 Temporary morbidity	SI = 4 Significant morbidity	SI = 5 Major or permanent	I = 6 eath
	May have required monitoring. No	Required monitoring &/ or investigation	Required monitoring &/or investigation	Required transfer to a higher care level		
		No change in vital signs	Some changes in vital signs	Significant changes in		

	No treatment required	Required minor treatment (e.g. simple	Required simple treatment (e.g. suturing)	Required emergency treatment / surgical		

Table 2. Flowchart showing Medication incident Management

SITUATION	GRADING (SEVERITY INDEX)	ACTION
When an incident occurs, the first priority for staff must be to manage the incident so that patients, staff or others involved are protected from the possibility of further harm, discomfort or inconvenience The member of staff who knows most about the incident should then 'grade' the incident	INCIDENT STAFF ACTION	<u>**Reporting incident**</u> 1. Patient safety incident 2. Incident of specific nature 3. Incidents requiring immediate management intervention 1. Manage the incident 2. Grade severity of the incident 3. Report incident through AIRS by the member of staff who know most about the incident

Based on the color grading for the incident, the member of staff should take the relevant action outlined in the flowchart above.	**SEVERITY INDEX:** **0, 1**	**1. Manage the incident through routine procedures** **2. Report to management within 48 hours**
This will involve reporting through AIRS and, for more serious incidents, will also involve	**SEVERITY INDEX:** **2,3**	**1. Management action needed** **2. Report to management within 24 hours**

immediate reporting to management in accordance with local procedures	**SEVERITY INDEX:** **4, 5, 6**	1. **Urgent management action needed** 2. **Report to management immediately**

Types & Causes of Medication Errors

Medication procedures in the ICU can be broken down into steps from drug prescription, transcription, dispensing to administration procedures with up to 40 steps being involved. The prescription process is initiated by a physician who enters the prescription into a dedicated computer system, prints, revises, and signs the prescription form. The nurse plans the corresponding medication timeframe and prepares any special care or apparatus required. In the central pharmacy, a pharmacist or his assistant prints the request, dispenses it and sends the ordered medications to the ICU. The medications are checked by a nurse, stores them in individual drawers identified by bed number. In due time, a nurse prepares the medication, checks the medication against the prescription and administers it to the corresponding patient.

Possible medication errors may arise during any of these steps. The types of medications errors in **Table 3** can be subdivided according to three key processes: prescribing, dispensing and administration processes.

Table 3 Types of Medication Errors

1. Prescribing	• Wrong Drug • Wrong Dosage form • Wrong Strength/dosage • Wrong Duration • Wrong Frequency • Wrong Route	• Wrong Abbreviation • Wrong Instruction • Wrong Patient • Double Entry • Drug Omission • Known Drug Allergy

2. Dispensing	• Wrong Drug • Wrong Dosage Form • Wrong Strength/dosage • Wrong Quantity • Known Drug Allergy	• Wrong Patient • Wrong Label information • Double Dispensing • Drug Omission
3. Administration	• Wrong Drug • Wrong Dosage Form • Wrong Dose • Wrong Flow rate • Wrong Patient • Wrong Route/method	• Wrong IV diluent • Wrong Time • Extra Dose • Dose Omission • Unordered Drug • Known Drug Allergy

A cross-sectional study of all hospital ICU and non-ICU medication errors reported to the MEDMARX system between 1999 and 2005 was performed in 2013 (Latif, A., 2013). **MEDMARX** is an anonymous, self-reported, confidential, de-identified, internet-accessible medication error reporting program that allows hospitals to report, track, and share medication error data.

There were 839,553 medication errors reported from 537 hospitals. Among them, ICUs accounted for 55,767 (6.6%) errors, of which 2,045 (3.7%) were considered harmful. Non-ICUs accounted for 783,800 (93.4%) errors, of which 14,471 (1.9%) were harmful. This study showed that the medication incidence in the ICU is 2 folds more serious compared with the general hospital cases. Errors most often originated in the administration phase (ICU 44% vs. non-ICU 33%). The most common error type was omission (ICU 26% vs. non-ICU 28%). Among harmful errors, dispensing devices (ICU 14% vs. non-ICU 7.1%) and calculation mistakes (ICU 9.8% vs. non-ICU 5.3%) were more commonly identified to be the cause in the ICU compared to the non-ICU setting.

In one study investigating the incidence types and causes of medication errors in ICU, a variety of factors were identified (Bohomol et al. 2009) The most plausible causes for the occurrence of medication errors in their study are listed in **Table 4**. The drug availability, stock and distribution problems accounted for over 50% of the causes of errors.

Table 4 Causes of Medication Errors in ICU (Bohomol E et al.2009)

Causes	Percentage (N = 300)
Drugs N/A at the institution	***41.0***
Stock or distribution problems in pharmacy	***16.3***
Transcription of the prescription failure to pharmacy	***11.0***
Communication failure among services	***8.0***
Prescription-related problems	***7.0***
Slips, memory lapses, and failure to check medication	***6.6***
Work overload and disruption	***5.0***
Others	***3.7***
Infusion pump problems	***0.7***
Protocols not follow	***0.7***

A retrospective evaluation of voluntarily reported medication errors over 4.5 years at a 647-bed academic medical center containing greater than 120 ICU beds identified a predominance of prescribing and drug omission errors (Risk Alert 2014). There were a total of 3252 medication errors reported with 541 and 2711 occurring in ICUs (16.6%) and general care units (83.4%) respectively. Primary types of medication errors were prescribing errors in the ICUs and drug omission errors in the general care units. Evaluation of these medication errors show the primary underlying cause were procedure/protocol not followed and knowledge deficit in the ICU and general care units. More frequently there was no contributing factor identified for medication errors in the ICUs.

A review of medication incidents among Hospitals under Hospital Authority in Hong Kong during a full year period (July 3013 – June 2014) in **Table 5** also revealed similar findings: the wrong strength dosage, wrong drug and dose omissions were the most common inpatients medication errors.

Local Data on Medication Incidents

Table 5. Medication Incident Statistics (Inpatient) (Jul-Dec 2013 / Jan-Jun 2014)

	Top 3 Most Common Error Types (Inpatient)		
	PRESCRIBING ***2013 / 2014***	***DISPENSING*** ***2013 / 2014***	***ADMINISTRATION*** ***2013 / 2014***
ank	**Inpatient**	**Inpatient**	**Inpatient**
st	Wrong Strength/ Dosage (30% / 40%)	Wrong Drug (50% / 30%)	Dose Omission (21% / 36%)
nd	Wrong Drug (0% /14%) *Wrong Patient* *14% / 0%*	Others (0% / 7%) *Wrong Strength /* *Dosage* *20% / 0%*	Wrong Drug (25%) *Extra Dose* *15% / 0%*

rd	Known Drug Allergy		Wrong Label Info and Wrong Strength/ Dosage (10% / 5%)			Wrong Dose (9% / 15%)	
No. of Incidents by Severity(Inpatient and Outpatient)							
Severity Index	0	1	2	3	4	5	6
Frequency 2013	4	**4**	**8**	**1**	**1**	**0**	**0**

(Summarized from the report of Risk Alert Issue 36 Jan 2015, A Risk management Newsletter for Hospital Authority Healthcare Professionals)

IMPACTS & CONSEQUENCES ON HEALTHCARE PROFESSIONALS & PATIENTS

Despite the best efforts in the midst of our daily work, medication errors can occur. Apart from causing considerable mortality, morbidity, and additional health care costs, it also poses substantial impact and consequences on health care practitioners and patients when a medication error occurs (Benkirane 2009).

Health care Professionals

However, little attention has been paid to the feelings of health care professionals involved in the incidents. They may experience uncomfortable feelings of personal vulnerability and professional fallibility; guilt, panic, remorse, self-doubt, and self-blame (Porter 2014). Some may be fearful about the safety of their patients and about disciplinary actions and punishment for their mistakes; fear malpractice lawsuits and possible criminal charges if a fatal incident occurs (Eric et al 2008). They may even have feelings of doubt about their professional abilities. Healthcare personnel involved in an incident can benefit from psychological support which can create an environment that fosters open and honest discussion about errors.

Nurses

Fears of negative consequences can be a major obstacle to accurate reporting of errors, with as many as 50% to 96% underreported. How nurses choose to respond to the occurrence of a medication error is recognized as an ethical imperative (Gallagher 2008). It is not an easy action to divulge medication errors. Nurses are still expected to provide responsible care and be fully accountable within their scope of practice. When medication errors are discovered, nurses have moral obligations of accountability and responsibility to account for the mistakes with disclosure (Porter 2014). It is also an opportunity to practice virtuous characteristics, particularly honesty and trustworthiness.

Research has demonstrated that four factors affect nurses' willingness to respond to an ethical dilemma or question, such as whether to report a medication error: ethics knowledge, clinical expertise, concern for ethical issues, and nurses' perceived level of influence in their unit (Hamric 1999). There are several strategies for ethical responses surrounding medication errors in ICU (Porter 2014):

1. Be accountable to yourself and your coworkers
2. Admit when medication errors occur
3. Resist the culture of "Name, Blame, and Shame"
4. Avoid workarounds in medication management processes

Whenever a patient has experienced an iatrogenic injury, disclosure of the incident should take place and should be guided by the following principles (Camiré 2009):

1. Perform in a timely fashion – as soon as possible after the injury, while ensuring the patient's well-being.
2. Perform in a quiet room free of interruptions.
3. Disclose facts without speculation, opinion or blame.
4. Use simple, unambiguous lay words.
5. Include an expression of sympathy.
6. Allow time for questions.
7. Document disclosure in the medical record.

Physicians

Physicians have the responsibility to write orders for medications and prescribe medications. At this vital first step, errors can occur in various ways, for instance, illegibility of orders, incomplete orders, incorrect doses, inappropriate doses for narrow therapeutic range for liver or kidney function, failure to verify allergies, and failure to reconcile medications leading to omitted medications or extra doses of medications (Bohomol 2009 & Frith 2013). In a study of prescribing errors. 7.53 errors per 1000 prescriptions were identified (Jayawardena 2007). Research explored the effect of perceived stress; caseload, perceived workload, and hours of sleep of physician on medication errors (Eric et al 2008). Clinicians should understand the reasons for medication errors from a human factor perspective.

Pharmacists and Dispensers

Hospital pharmacies dispense large numbers of medication doses for hospitalized patients. Previous studies have also reported conflicting rates of pharmacy dispensing errors, ranging from 0.0041% to 3.6%. One study relied on self-reporting to detect dispensing errors and identified underestimation of the incidence of these errors (Brixey 2008). The study found an overall unweighted pharmacy dispensing error rate of 3.6% (5,075), of which 2.9% (4, 016) were detected errors and 0.75% (1,059) was undetected errors. Several factors identified in the dispensing process included human fatigue, process workarounds , confusion surrounding look-alike and sound-alike medications, and repetitive tasks for filing and checking the dose dispensed. The process involved routinely used medication; the high volume of medications filled and verified can also lead to a high number of errors.

Patients and Family

A systematic review of direct observation evidence over medication errors in critically ill adults showed that increased monitoring was the most common consequence of medication errors, whilst life-threatening and fatal adverse events were rare (Kiekkas 2011).

Patients in the ICU and their families are most vulnerable. They have limited ability to control the environment and invasive technology and a sense of intimidation by the critical illness experience. A climate of trust is indispensible for patients and families to overcome their vulnerability and powerlessness (Porter 2014).

Risk Factors and Prevention Measures

Risk Factor

A thorough root causes analysis is a common structural tool conducted in the organization for revealing underlying system deficiencies and risk factors, for both error analysis and development of action for system improvement and prevention measures. Medication errors (MEs) are more common in the ICU due to poly-pharmacy and the stressful environment. The underlying cause for such errors may be professional practice, health care products, procedures and system related (Agalu 2012). Medication errors are associated with human factors that include stress, high workloads, knowledge deficit and performance deficits. Factors contributing to medication errors are frequent interruptions, communication problems, and poor fit of health information technology to the workflow of providers (**Table 6)** (Frith 2013). The potential risk factors for medication errors in ICU are categorized in **Table 7** (Moyen 2008).

RISK FACTORS & PREVENTIVE MEASURES

Table 6 Contributing factors for MEs - System related (*Frith, 2013, p391)*

Lighting
Noise level

Frequent interruptions and distractions Training Staffing Lack of availability of health care professional Assignment of placement of a health care provider or inexperienced personnel System for covering patient care Policies and procedures Communication systems between health care practitioners Patient counseling Floor stock Preprinted medication orders Others

Table 7. Potential risk factors for medication errors (MEs) in ICU (Moyen 2008)

Factors	Risk factors	
Patient	Sedation	Patient unable to participate in care and defend themselves against errors
	Communication	Verbal and written communication

Health care providers		Misinterpretation of the order
	Staff performance	Valuable insight into unsafe practice Knowledge and performance deficit
Medications	Types of medications	Frequent boluses and infusions dose Complex mathematical calculations of dosage Programming of infusion pumps
	No. of medications	Many medications prescription
	Labeling	Immediate container labels of product - Proprietary (trade)name confusion - Established (generic) name confusion
	No. of interventions	Increased risk of complications
ICU environment	Complex environment	multitasking and fast pace of medical care High stress High turnover of patients and providers
	Emergency admissions	Risk of adverse event

Multiple care providers	Challenges the integration of different care plans

Prevention measures

Improved medication safety can be accomplished by optimizing the safety of the medication process, eliminating situational risk factors, and providing strategies to both intercept errors and mitigate their consequences.

The safest and most efficient means of improving patient safety is to improve the safety of the medication process (Moyen 2008). Strategies in **Table 8** that have been shown to be successful including medication standardization, computerized physician order entry (CPOE), bar code technology, and use of computerized intravenous infusion devices.

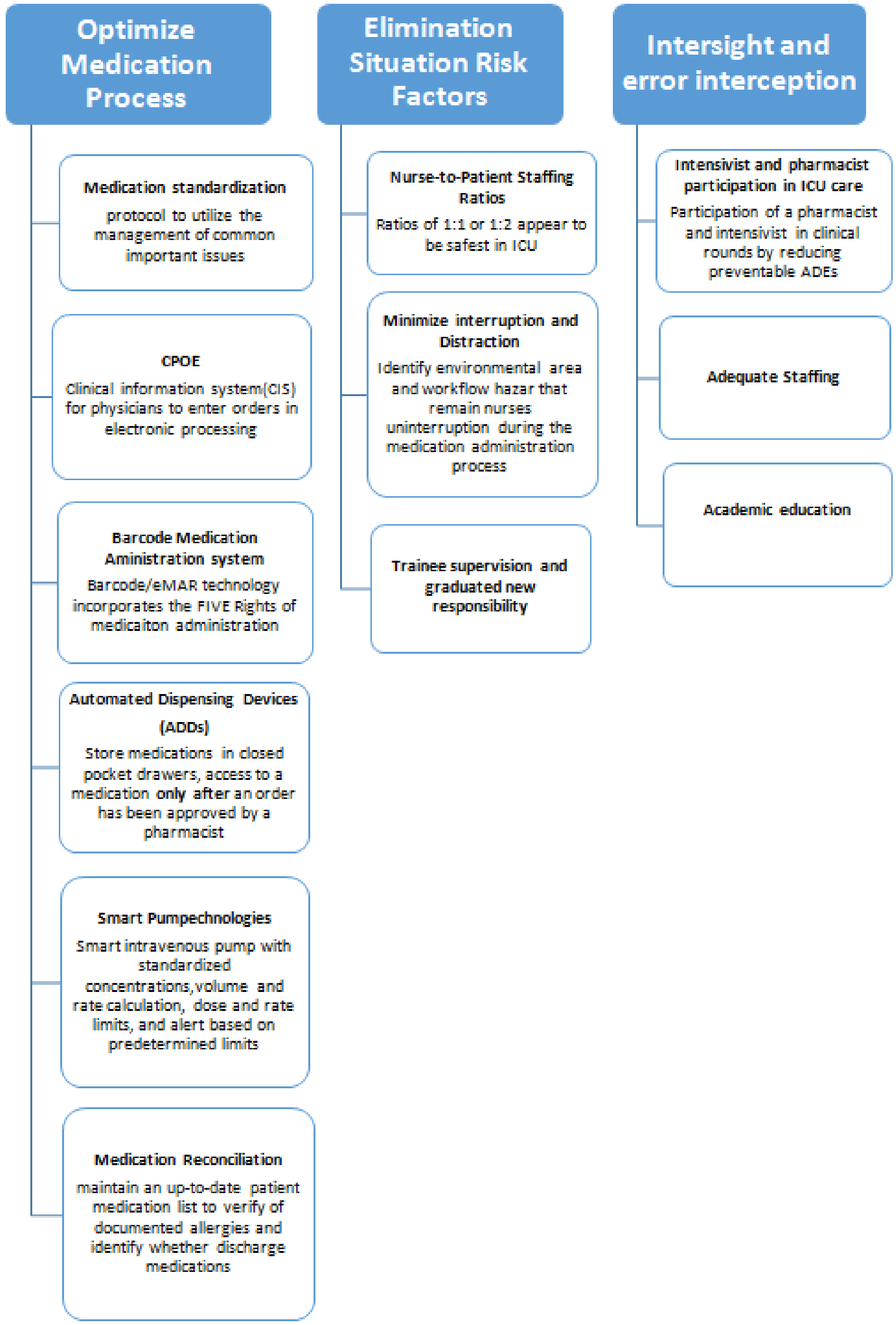
Table 8. Strategies to Prevent MEs

Reorganize the medication process
1. Medication standardization 2. CPOE and clinical decision support 3. Bar code technology 4. computerized intravenous infusion devices 5. Medication reconciliation
Eradicate situational risk factors
1. Avoid excessive working hours 2. Minimize interruptions and disturbances

3. Trainee supervision and one's own responsibility
Mistake and error interception
1. Adequate staffing 2. Intensivist and pharmacist participation in ICU care 3. Incorporation of quality assurance into academic education

The high-risk nature of medication administration, particularly in the critical care setting, is contributing factors that can lead to medication-related safety events. Recently adopted medication safety technologies such as computerized provider order entry (CPOE), bar code medication administration systems and smart pump technology are showing significant impact in decreasing risks associated with medication use as summarizes in **Table 9** (Bates 1999, Poon 2010, Rothschild 2005 & Keohane 2005). CRICO's Comparative Benchmarking System (CBS) data show that medication-related malpractice claims have decreased approximately 40 percent over the past five years, likely due in part to the adoption of new safety technologies.

Table 9. Preventive Measures for Medication Errors



Recommendations

Nurses often represent the 'last line of defense' against medication errors. However, interruptions during medication administration process can range from questions from other colleagues, patients, families; monitors, alarms, and pagers to patient activity (Academic

Medical Center 2012). Some interruptions are obviously necessary for the swift communication of critical clinical information. As a result, efforts should only be aimed at reducing those interruptions that are not relevant to patient care (Redding 2009). Whereas the positive effects of delivering real-time clinical information are enhanced (Brixey 2008). On the other hand, there are also limitations associated with innovative technologies for medication safety. Providers should be aware to avoid over-reliance on technology. Critical thinking is of utmost importance, not only as it relates to drug dosage, timing, and selection, but also as it relates to the overall patient condition, clinical situation, and interpretation of clinical data (AMC 2012).

To implement effective strategies for medication safety through decreasing risks, both **Table 10 and 11** highlight the essential practice recommendations (Academic Medical Center 2012 & Frith 2013). ICU nurses play a crucial role not only in setting strategic goals for medication safety but also in executing those goals and maintaining a culture of safety. Nevertheless, patient safety is the top priority in providing high-quality health care, and ensuring the safety of patients is everyone’s responsibility and challenge.

Table 10. Strategies for Improving Medication Safety (AMC, 2012)

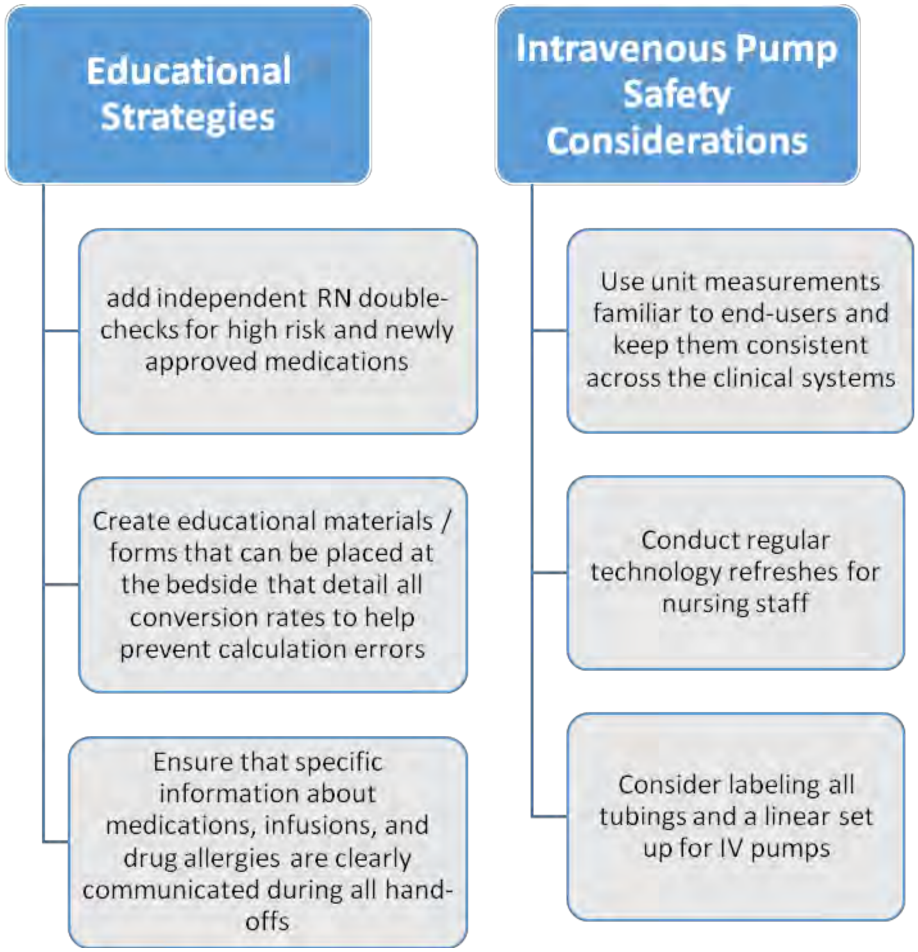

Educational Strategies
add independent RN double-checks for high risk and newly approved medications
Create educational materials / forms that can be placed at the bedside that detail all conversion rates to help prevent calculation errors
Ensure that specific information about medications, infusions, and drug allergies are clearly communicated during all hand-offs
Intravenous Pump Safety Considerations
Use unit measurements familiar to end-users and keep them consistent across the clinical systems
Conduct regular technology refreshes for nursing staff
Consider labeling all tubings and a linear set up for IV pumps

Table 11. Interventions to improve Medication safety in ICUs (Frith, 2013)

Medication Safety Interventions
Culture
Assess baseline culture of safety
Utilize a closed loop communication (check back) among interprofessional team
Encourage nameless reporting system of errors and near-misses
Encourage speak up accountability
Examine medication errors in systematic approach and in complete picture
Consider slips and lapses as symptoms of preoccupied failure
Person
Encourage countercheck with other providers when prescribing medications
Review and share causes and interceptions for medication errors from a cognitive processing perspective
Reschedule ICU nurses working hours between shifts
Tasks
Minimize multitasking during medication preparation and administration
Simplify protocols or procedure steps for medication safety
Increase automation technology of tasks whenever possible
Technology

Select closed loop technology for medication prescribing, dispensing, and administration Educate staff and make changes to technology
Environment Provide quiet best environment for preparation and administration of medication Post warning signage of high-alert medications carefully Place patient medications in locked drawers in patient rooms

PATIENT AND FAMILY SATISFACTION IN THE ICU

Promoting patient and family satisfaction with care is a key component of providing quality care in the ICU (de-la-Cueva-Ariza et al., 2013). Traditionally, the goal of intensive care nursing has primarily focused on the physiological and psychological impact of life-threatening illnesses on individual patients. By incorporating the concept of patient to include the family, the critically ill patient's well-being can be improved (Lee, Chien, & Machenzie, 2000). For that reason, both patient and family experience is important for patient- and family-centered care in the ICU.

Patient and family satisfaction has become an acknowledged quality metric in the ICU. A number of studies have been conducted internationally which focus on improving the patient experience in the ICU. A pilot study was conducted in a mixed adult ICU in Netherland using a self-developed questionnaire which included 60 questions in eight domains (General satisfaction, Reception, Physical care, Mental care, Empathy and attention, Communication and information, Surroundings and Physical discomfort) to measure the level of patient satisfaction and to identify its influencing factors on ICU patients. Ninety-eight patients were interviewed. The mean overall patient satisfaction score was 4.60 out of 5. Communication and information emerged to be significant in predicting general satisfaction. Moreover, elderly, female, Dutch nationality, longer ICU stay, long duration of mechanical ventilation and a high Minimal Mental State Examination score were related to less satisfied patients (Jansen et al. 2008).

Patient satisfaction has been associated with nursing work environment. Boev (2011) used a 26-item instrument to measure level of satisfaction of critically ill patients with care and to examine the relationship between nurses' perception of work environment and patient satisfaction in four adult ICUs in United State. The results showed that overall quality of nursing had the highest score (4.5 out of 5), followed by nurses' friendliness (4.4 out of 5), and patient's satisfaction of pain control (4.4 out of 5). Critically ill patient's satisfaction with preparation for

ICU discharge had the lowest scores (4.1 out of 5). Intensive care nurses reported moderate satisfaction with work environment, with perception of the role of their nurse manager having a strong influence on satisfaction scores. Perception of nurse manager leadership and capability was significantly associated with patient satisfaction. The relationship between nurses' perception of their nurse manger and overall patient satisfaction suggests hospitals should consider putting more resources in nursing work environment improvement and nursing leadership empowerment.

However, conducting patient satisfaction surveys in the ICU can be challenging. Apart from whether critically ill patients can consciously recall their stay in the ICU, and have the ability to judge quality of health care service, the timing to perform the survey is another major issue. Most patient satisfaction surveys are conducted upon patient discharge and reflect the care they received from the unit from which they were discharged. Rarely are patients directly discharged to home from the ICU, and obtaining information related to patient satisfaction with ICU nursing care is therefore limited (Stricker et.al., 2011). Additionally, there are a lack of validated instruments to evaluate patient satisfaction with care in the ICU and the absence of standardized instruments make benchmarking of patient satisfaction data difficult (de-la-Cueva-Ariza et al., 2013).

INSTRUMENTS MEASURING FAMILY SATISFACTION

Studies demonstrate that if a critically ill patient is unable to rate satisfaction with care in the ICU, family members can be taken as appropriate surrogates (Stricker et.al. 2011). Therefore, various assessment tools had been developed to evaluate family's satisfaction in ICU (Heyland & Tranner, 2001; Wasser et al. 2001). A search of literature had shown that there are at least three assessment tools commonly used in ICU to measure the level of family satisfaction.

FAMILY SATISFACTION IN INTENSIVE CARE UNIT

The FS-ICU-34 was developed by Heyland & Tranmer (2001). It was designed to measure the family satisfaction with care provided in the ICU. The origin FS-ICU consists of 34 items, it was conceptualized into two domains: satisfaction with overall care (18 items), and satisfaction with decision making (16 items). Content validity, clarity and readability had been tested. Cronbach's alpha (internal consistency) ranged from 0.74 to 0.95, and test and retest reliability was 0.85 (Heyland & Tranmer, 2001).

The FS-ICU-34 was further refined and validated by Wall and his colleagues (2007), and became shortened FS-ICU-24. Shortened FS-ICU-24 consists of 24 items, measuring two domains as well: "Satisfaction with Care" (14 items) and Satisfaction with Decision Making (10 items). The Cronbach's alpha score were 0.92 and 0.88 for the Satisfaction with Care and the Satisfaction with Decision Making respectively. The two subscales showed good correlation with each other (Spearman's 0.73, p <0.001) which "suggesting that a single scale for the entire instrument was reasonable" (Wall, et al., 2007, p.275). In validity testing, the FS-ICU-24 was significantly correlated with the Family-Quality of Dying and Death (Family-QODD) questionnaire total score (Spearman's 0.56, p < 0.001) (Wall, et al., 2007)

FS-ICU had been translated and validated for cross-cultural use. To date, it had been translated into French, Chinese, Portuguese, Hebrew, Spanish and Swedish (Canadian Association of Research at the End of Life Network, n.d.) as it is a valid and reliable tool for assessing family satisfaction in the ICU. The Pamela Youle Nethersole Eastern hospital in Hong Kong currently adopts FS-ICU-24 as an instrument to measure the family satisfaction of care in ICU.

CRITICAL CARE FAMILY NEED INVENTORY (CCFNI)

The CCFNI is a 46-item, 4-point Likert-type questionnaire with 45 specific items and an open-ended item to identify a need that was not listed on the questionnaire. The CCFNI was developed and modified from Molter's (1979) instrument by Leske in 1986 (Lee & Lau, 2002). Construct validity and internal consistency of CCFNI were examined by Leske (1991), and were established by performing factor analysis. Five dimensions of CCFNI were identified, and were labeled as need for support, comfort, information, closeness and reassurance (Leske, 1991). The internal consistency alpha coefficient of the total CCFNI was 0.92, and the Cronbach's alphas of five dimensions were between 0.61 and 0.88. This indicated that CCFNI had acceptable internal consistency.

The CCFNI has been widely used in studies and in different cultures in large scale studies (Azoulay, et al., 2001; Damghi et al., 2008; Wilson, Cavanaugh, et al., 1998). It has been translated into Arabic (Damghi et al., 2008), Spanish (Gomez-Martiinez, Arnal, & Julia, 2011), Chinese (Wong, 1995).

CRITICAL CARE FAMILY SATISFACTION SURVEY (CCFSS)

The CCFSS was developed and validated by Wasser, Pasquale & Matchett et al. in 2001. Wasser and colleagues (2001) believed that it is important to include all dimensions of care when evaluating family satisfaction with care provided in ICU.

The CCFSS consists of 20 items; it is used to measure family satisfaction with overall care in ICU. The content and construct validity were examined by Wasser and colleagues (2001), support that the CCFSS was reliable and valid; the Cronbach's alpha score was 0.93 for the 4-factor model, and 0.91 for 5-factor model. The CCFSS has five subscales: assurance (the need to feel hope for a desired outcome), information (the need for consistent, realistic and timely information), proximity (the need for personal contact and to be physically and emotionally near patient), support (the need for resources, support system, and ventilation), comfort (the need for personal comfort). Subscale correlation were not lower than 0.75 for the five-factor model and 0.856 for the four-factor model (Wasser et al., 2001).

Clinical Exemplar: FAMILY SATISFACTION IN HONG KONG ICU

Reporting family members' feedback and satisfaction of care is a key domain to provide transparency and improve the overall quality of intensive care. Two quantitative studies were identified using the CCFNI to investigate the needs and satisfaction of family members of critically ill patients in Hong Kong.

Lee, Chien and Machenzie (2000) conducted a descriptive study consisting of 30 family members who had a relative admitted to a Hong Kong ICU to explore their needs and their perception of having their needs met. Among the five need categories, reassurance and information were the most important categories. The 5 most important family needs were ‘to know the expected outcome’, ‘to be assured that the best care possible is being given to the patient’, ‘to know specific facts concerning the patient’s progress’, ‘to have explanations given that are understandable’ and ‘to see the patient frequently”. Over 80% of family members perceived nurses as the most appropriate persons to meet the family needs. Additionally, the five family needs that could be best met by nurses were ‘to talk to same nurse everyday’, ‘to be called at home about changes in the patient’s condition’, ‘to receive information about the patient at least once a day’, ‘to have directions as to what to do at the bedside’ and ‘to help with the patient’s physical care’. The study identified that female family members had higher ratings in the unmet need scores and the 5 highest ranking of the unmet needs included ‘to talk to the doctor daily’, ‘to visit any time’, ‘to help with the patient’s physical care’, ‘to feel it is alright to cry’ and ‘to talk about negative feelings such as guilt or anger’.

Another similar descriptive study was carried out in Hong Kong to investigate the needs of family members of ICU patients and to measure the extent of needs being met. The study recruited 40 adult family members of critically ill patients using convenience sampling methods. The mean scores of five need categories ranged from 2.5 to 3.7(possible range 1-4). The reassurance category was ranked as the most important then followed by closeness, information, comfort and support category. More than half (58.4%) of the family members of critically ill patients replied that their needs were met. The top 5 needs that were met most were ‘to know the expected outcome’ (95.0%), ‘to have friends nearby for support’ (95.0%), ‘to be assured that the best care possible is being giving to the patient’ (95.0%), ‘to feel that hospital personnel care about the patient’ (94.9%) and ‘to have visiting hours start on time’ (92.5%) and they were met by nurses and doctors. Needs of the reassurance category were met most (86.7%), then the closeness (61.6%), information (56.8%), support (54.7%) and comfort (35.4%) categories. Nine out of 10 needs that were met most were perceived as important which implies the health care providers satisfactorily fulfilled family members' needs. On the other hand, the top 5 needs were met least were 'to have comfortable furniture in the waiting room'(12.5%), ' to have a toilet near the waiting room' (12.5%), ' to have good food available in the hospital (18.7%), 'to have the waiting room near the patient'(22.5%) and 'to visit at any time'(25%). (Lee & Lau, 2003).

Apart from the two studies using CCFNI, the Hong Kong Association of Critical Care Nurses (HKACCN) conducted a pilot study in 2004 to examine both patient and family satisfaction with nursing care in 3 Hong Kong ICUs. 30 samples from patients and 30 samples from family members of ICU patients were recruited. Patients who are unconscious; with legal implication and stayed in ICU less than 48 hours were excluded in the study. ICU patient and family satisfaction questionnaires were developed and validated by expert panel. HKACCN found that:

*** Higher percentage *of graduate nurses*** showed a positive effect on patient/ patient's family satisfaction about the nursing care they received **(p =0.03) / (p =0.01)**

*** Higher percentage *of nurses with formal ICU training*** showed significant effect on patient/ patient's family satisfaction about the nurses' performance (p**=0.00)** / (p**=0.05).**

*** Higher Nurse:Patient ratio** showed significant effect on patient/patient's family satisfaction about the nurses' performance **(p=0.00) / p=0.07).**

(HKACCN 2004). Kosco & Warren, (2000) found that, "The less experienced nurses may not be as prepared to deal with the needs of family members, as nurses with more education may have more experience with communication skills and may find it easier to keep the family members informed of the condition of their loved ones."

Though small sample sizes and or single center setting limited the generalizability of the aforementioned studies, they highlight areas such as providing psychological support, giving information to update patient's progress, allowing being close to the patient and having comfortable hospital environment and facilities, deserve more attention by Hong Kong ICU nurses in an attempt to raise the satisfaction with needs met of the family members of critically ill patients.

INTERVENTION TO ENHANCE FAMILY SATISFACTION WITH ICU CARE

Family needs assessment

To enhance satisfaction level of family members of critically ill patients, family-centered care should be adopted in the ICU. Family-centered care is an approach to care that recognizes the needs of patient's family members plus the essential role that family members take part in during patient's illness (Henneman & Cardin, 2002). Studies have identified the incongruence in the perception on the importance of family needs between families members and nurses (Lee et al 2000; Maxwell et al 2007). It is beneficial for ICU nurses to assess the perception of family needs from a multidisciplinary care perspective, and to ensure that the plan of care is truly family care based (Henneman & Cardin, 2002). Therefore, strategies to improve family satisfaction on information needs and assurance & support needs as well as proximal needs are suggested for consideration.

STRATEGIES TO IMPROVE FAMILY SATISFACTION ON INFORMATION NEEDS

Use of printed information is an effective method in meeting family information needs. Azoulay et al. (2002) conducted a randomized trial in 34 French ICUs to compare comprehension of diagnosis, prognosis, treatment, and satisfaction with information given by ICU caregivers. The families in the intervention group received a family-information leaflet in addition to standard information. The results showed that family members were significantly more satisfied and had better comprehension of the ICU than the control group (Azoulay et al., 2002). In Hong Kong, many ICU nurses have participated in developing leaflets or printed information brochures about critical illness, treatment procedure and family orientation, and have made use of the printed information aids to facilitate patients and family members' understanding of the disease process, outcomes and ICU environment.

The formal structured family meeting is another approach designed to enhance communication in the ICU. The family meeting is an important forum for discussion about the patient's condition, prognosis, and care preferences; for listening to the family's concerns; as well as for decision making about suitable treatment goals (Gay, Pronovost, Basset, & Nelson, 2009). Lautrette et al. (2007) conducted a randomized controlled trial in 22 ICUs in France and found that the use of a printed informational brochure with a proactive protocolized conference with families of patients dying in the ICU significantly lessened the prevalence and level of family member anxiety and depression and posttraumatic stress. Another study using a before-and-after design evaluated the effect of regular, structured formal family meetings on patient outcomes among long-stay ICU patients. The intervention called Intensive Communication System intervention, consisted of a structured formal family meeting conducted by two advance practice nurses (APN) within 5 days of ICU admission and weekly thereafter. Each meeting discussed medical updates, and patient's preferences for treatment, goals of care, and patient condition for determining effective treatment. Despite no significant differences between control and intervention patients in length of stay and time to tracheostomy, the APN-facilitated family meetings increased participation of bedside nurses and social workers in the family meetings. Additionally, more time was dedicated for family meetings (Daly et al., 2010). Given that the ICU nurse is always at the bedside engaging in communication with patients and families, ICU nurses can proactively participate in formal structured family meeting to improve communication with family and in turn fulfill family informational needs.

STRATEGIES TO IMPROVE FAMILY SATISFACTION ON ASSURANCE AND SUPPORT NEEDS

The use of a needs-based education program can also have an impact on family satisfaction. A quasi-experimental study with pre- and post-test design was conducted in Hong Kong ICUs to examine the effect of a needs-based education program on the anxiety levels and satisfaction of psychosocial needs of their families. Both family members in control and intervention groups obtained information about the ICU setting and practice on the first day of the patient’s ICU stay. Family members in intervention group received a pamphlet containing information about the ICU facilities and had two consecutive 1 hour education sessions conducted by an assigned nurse during the second and third day of the patient’s ICU stay. The content of the education program was based on the individual family needs assessment. Additionally, daily telephone follow up was made to family members. After the needs-based intervention, the family members of the intervention group reported significantly lower levels of anxiety and higher levels of satisfaction related to information, support and assurance needs (Chien et al 2006).

STRATEGIES TO IMPROVE FAMILY SATISFACTION ON PROXIMITY NEEDS

Regarding family visitation, studies have demonstrated that patients wish to have their family visit more frequently and families want visiting hours to be more flexible, highlighting that restrictive visitation may not fulfill families need to be close to critically ill patients (Halm and Tilter, 1990; Roland, Russell, Richards, & Sullivan, 2001). Yet globally, flexible open visitation is not a standard of care in the ICU. The American College of Critical Care recommends that the patient, family and nurse determine visiting schedule collectively and advocates for open visitation in adult ICU based on case by case (Judy et al., 2007). Lee (2009) performed a quasi-experimental study in a Hong Kong ICU to investigate the effects of contract visitation on the satisfaction level of meeting families' needs. Families in the intervention group followed a contractual visiting practice that permitted an individualized approach to family visits while the control group was subjected to the usual restrictive practice. The results showed that families of intervention group had significantly higher satisfaction score in proximity and support need attainment.

In summary, promoting patient and family satisfaction is a NSOI that is used on an international basis to improve the quality of care provided in the ICU. Sharing global strategies for promoting patient and family satisfaction can help to enhance the ICU experience for patients, families and ICU caregivers. Internationally, nurses play an important role in promoting patient and family satisfaction with ICU care. Dissemination of specific strategies that have resulted in improved ICU care such as open visitation, family presence on rounds, family presence during resuscitation or invasive procedures, and other initiatives including music therapy or pet visitation in the ICU can help to promote optimal care for patients and families in the ICU (Society of Critical Care Medicine, 2015).

CHECK YOUR PROGRESS: Assess your understanding of key points from this e-chapter.

1. Which of the following is a nurse sensitive outcome indicator?

A. nursing turnover rates

B. nursing job satisfaction rates

C. peripheral catheter insertion rates

D. pressure ulcer rates

Answer: D

2. True or False: An anticipated physiologic fall is associated with intrinsic factors such as aging, altered mental state, unsteady gait and sensory deficits, which can be prevented by specific interventions after assessment.

Answer**:** True

3. Which of the following is considered an extrinsic factor related to falls in the ICU?

A. Patient age

B. Patient mobility level

C. Patient de-conditioning

D. ICU equipment including tubes, or drainage bags

Answer: D

4. System factors contributing to the displacement of tubes, lines and drains in the ICU include all of the following except which factor?

A. Poorly secured tube/drain/line

B. Staff to patient ratio

C. Patient room location in the ICU

D. Patient positioning

Answer: D

5. Medication procedures in the ICU can be broken down into steps from drug prescription, transcription, dispensing, and administration procedures. How many steps have been identified in the total process?

A. 10

B. 20

C. 30

D. 40

Answer: D

6. Which of the following is NOT an appropriate ethical response to medication error management?

   A. Be accountable to yourself and your coworkers

   B. Admit when medication errors occur

   C. Name, Blame, and Shame those who make serious errors.

   D. Avoid workarounds in medication management processes

Answer: C

7. True or False: Globally, flexible open visitation is a standard of care in the ICU

Answer: False

8. True or False: Female family members may feel the need to express grief and anger over the plight of their loved one in ICU

Answer: True

9. Patients falls are most accurately measured using the following units:

   A. Falls per 1000 occupied bed days

   B. Average falls per admitted patient, excluding ICU

   C. Total falls that resulted in an ICU admission

   D. Falls per total bed capacity.

Answer: A

10. The HKACCN study of patient and family satisfaction with nursing care in 3 Hong Kong ICUs should that all of the following improved satisfaction with care except?

    A. High percentage of graduate nurses

    B. High percentage of nurses with formal ICU training

    C. High percentage of male nurses

    D. High Nurse:Patient ratios

Answer: C

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