HSIB

HEALTHCARE SAFETY INVESTIGATION BRANCH

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Summary

The use of an appropriate flush fluid with arterial lines

Independent report by the
Healthcare Safety Investigation Branch NI-000832

August 2022

Providing feedback and comment on HSIB reports

At the Healthcare Safety Investigation Branch (HSIB) we welcome feedback on our investigation reports. The best way to share your views and comments is to email us at **enquiries@hsib.org.uk** or complete our online feedback form at **www.hsib.org.uk/tell-us-what-you-think**.

We aim to provide a response to all correspondence within five working days.

About HSIB

We conduct independent investigations of patient safety concerns in NHS-funded care across England. Most harm in healthcare results from problems within the systems and processes that determine how care is delivered. Our investigations identify the contributory factors that have led to harm or the potential for harm to patients. The safety recommendations we make aim to improve healthcare systems and processes, to reduce risk and improve safety.

We work closely with patients, families and healthcare staff affected by patient safety incidents, and we never attribute blame or liability.

Considerations in light of coronavirus (COVID-19)

A number of national reports were in progress when the COVID-19 pandemic significantly affected the UK in 2020 and 2021. Much of the work associated with developing the reports necessarily ceased as HSIB's response was redirected.

For this national report, the investigation was initially paused, but then restarted due to its association with COVID-19. The processes HSIB used to engage with staff and families had to be adapted. Changes are described further in this report.

A note of acknowledgement

We would like to thank Keith's family whose experience is documented in this report. We would also like to thank the healthcare staff and stakeholders who engaged with the investigation for their openness and willingness to support improvements in this area of care.

About the patient

The picture on the shelf in the family lounge shows Keith at the heart of a large extended family. Keith was married for 44 years and has three daughters and three grandchildren who describe him as a "fun family man".

Keith worked and volunteered as a marshal at the Silverstone racecourse, where he shared a love of motor racing with his family.

He was well-known and well-loved within his community with a reputation for his ability to fix everything and anything from cars to cupboards. He had a particular love for wood, which he collected and stored wherever he could find space at home. He was a man people turned to with their everyday problems and he was always willing and equally very able to lend a hand.

About this report

This report is intended for healthcare organisations, policymakers and the public to help improve patient safety in relation to the use of a flush fluid and blood sampling from an arterial line in people who are critically ill in hospital. For readers less familiar with this area of healthcare, medical terms are explained in **section 1** and throughout the text.

Our investigations

Our investigators and analysts have diverse experience of healthcare and other safety-critical industries and are trained in human factors and safety science. We consult widely in England and internationally to ensure that our work is informed by appropriate clinical and other relevant expertise.

We undertake patient safety investigations through two programmes:

National investigations

Concerns about patient safety in any area of NHS-funded healthcare in England can be referred to us by any person, group or organisation. We review these concerns against our investigation criteria to decide whether to conduct a national investigation. National investigation reports are published on our website and include safety recommendations for specific organisations. These organisations are requested to respond to our safety recommendations within 90 days, and we publish their responses on our **website**.

Maternity investigations

We investigate incidents in NHS maternity services that meet criteria set out within one of the following national maternity healthcare programmes:

- Royal College of Obstetricians and Gynaecologists' 'Each Baby Counts' report
- MBRRACE-UK 'Saving Lives, Improving Mothers' Care' report.

Incidents are referred to us by the NHS trust where the incident took place, and, where an incident meets the criteria, our investigation replaces the trust's own local investigation. Our investigation report is shared with the family and trust, and the trust is responsible for carrying out any safety recommendations made in the report.

In addition, we identify and examine recurring themes that arise from trust-level investigations in order to make safety recommendations to local and national organisations for system-level improvements in maternity services.

For full information on our national and maternity investigations please **visit our website**.

Executive Summary

Background

This investigation aimed to understand the risks for patients associated with blood sampling from arterial line systems used in adult critical care. An arterial line is a system used to continuously monitor a patient's blood pressure and intermittently monitor blood glucose levels by taking a blood sample from the arterial line. A thin tube called a cannula is inserted into an artery, usually in the person's forearm, and tubing is used to attach a device called a transducer. This is connected to a bag of fluid (the flush fluid) and the pressure change of the fluid within the connecting plastic tubing transmits to an electrical monitoring device. This device displays the blood pressure within the artery as a continuous wave line on the monitoring screen. Arterial lines are used in other areas of healthcare and the findings of this investigation may also be relevant to these areas.

The selection and attachment of the incorrect flush fluid is a recognised risk in the use of arterial lines. When a flush fluid contains glucose rather than saline (0.9% sodium chloride) and a blood sample from an arterial line is contaminated, a false high blood glucose is recorded. This will mislead the clinician who may start the patient on insulin, which controls blood sugar levels. This may lead to unrecognised and dangerous levels of hypoglycaemia (low blood glucose levels), which can lead to the patient going into a coma. Careful monitoring of blood glucose levels has become established practice for critical care patients. It provides the information clinicians need to understand whether treatment is appropriate to correct an imbalance in blood glucose levels. Blood glucose monitoring using an arterial blood sample is recommended in critical care environments.

As an example, which is referred to as 'the reference event', the investigation reviewed the care of a patient named Keith. Keith received treatment to drain his gallbladder but then became very unwell. He was admitted to a critical care unit with significantly low blood pressure and sepsis (a reaction to infection that causes a person's body to damage its own tissues and organs). An arterial line was inserted, and the incorrect flush fluid was connected to the transducer. The use of the incorrect flush fluid led to the contamination of the blood samples taken from the site of the arterial line, which consequently misled clinicians to give Keith an unnecessary and potentially harmful treatment.

This investigation's findings, safety recommendations and safety observations aim to demonstrate the risk associated with the set-up of the arterial monitoring line and use of the correct flush fluid and to improve care for patients across the NHS.

The reference event

Keith was 66 years old and was recently retired. After feeling unwell for 25 days and attending medical appointments to investigate his gallbladder, he was admitted to hospital. Following an investigation and the drainage of his gallbladder his condition deteriorated. He was admitted to the critical care unit late in the year of 2020 with sepsis and very low blood pressure. Keith was medically unstable and required numerous medications and devices to be attached to him to enable accurate monitoring of his condition.

The insertion of the arterial line was completed around 16:20 hours. The doctor inserted a cannula into an artery in Keith's arm, while a nurse went to look for the correct equipment, an arterial line (marked red) and a 500ml bag of saline (sodium chloride 0.9%) flush fluid. Saline is the recommended flush fluid for an arterial line and other fluids should not be used for this purpose. The nurse looked first within the 'lines' drawers at the bedside (intended to include all necessary equipment for the insertion of an arterial line). When unable to find the correct arterial line transducer set, the nurse looked in two other areas of the critical care unit. They also collected the bag of saline flush fluid from the drug cupboard. The nurse was aware that the cannula had been inserted and the blood would clot and block the line without the arterial line and saline flush fluid attached. They returned to the bedspace with a blue line central venous transducer set. The line and bag of flush fluid were checked and attached. The risk of attaching a blue transducer line was recognised by staff, as a blue transducer line is intended to be connected via a vein and can indicate it is safe to administer medication, which would not be safe through an arterial transducer line.

The need to change the line was prioritised by staff but the nature of Keith's condition created several competing tasks. Keith's blood glucose levels were found to be low. A different nurse went to retrieve a bag of glucose so that a glucose infusion (where glucose in a liquid solution is delivered via a patient's vein) could be commenced to increase Keith's blood glucose levels. Unable to locate the required strength of glucose, the nurse returned with two alternative strengths for the doctor to select for treatment. While collecting the glucose the nurse also found and returned with the correct red arterial transducer line. The red arterial transducer line and remaining bag of glucose were left together by the bed. The other nurse interrupted their current task and collected both items to replace the blue transducer line that was in position with the correct red arterial transducer line. They replaced the central venous transducer set (blue line) and the correct saline flush fluid with the arterial transducer set (red line) and the incorrect bag of fluid containing glucose as the flush fluid.

Subsequent blood samples taken from Keith's arterial line were contaminated with the flush fluid containing glucose. This led clinicians to conclude that Keith was suffering from high blood glucose levels and at risk of further harm. An infusion of insulin, the required treatment for high blood glucose, was administered for approximately 8 hours. This treatment reduced Keith's blood glucose levels to below the recommended limit. The incorrect fluid was identified the next day, during morning safety checks completed by the nurse taking over Keith's care. The treatment of insulin was stopped, and glucose administered to correct the blood glucose levels.

Keith had a brain scan on the same day, which concluded at that time there was no neurological damage associated with the abnormal blood glucose levels. He was discharged from the critical care unit 15 days after his admission following care for his underlying condition. Sadly, Keith died of COVID-19 later during his hospital stay.

The national investigation

HSIB was contacted by the Department of Health and Social Care in response to receiving a prevention of future deaths notice from a coroner's investigation into the death of a woman aged 57 years. The investigation was completed on the 7 September 2020 and concluded that the use of a solution containing glucose instead of saline, the recommended fluid to flush an arterial line, contributed to the patient's death.

HSIB identified Keith's case as a similar patient safety incident. Although the event did not result in the death of a patient, it involved a similar sequence of events and the same error was identified.

Findings

The key findings from the investigation include:

- The physical layout and design of the clinical and storage areas will influence how reliably staff are able to select and collect similar-looking equipment and medication.

- The labelling of bags of fluids, similar looking medications and manufacturers' packaging reduce the reliability of selecting the correct flush fluid in the context of a critical care unit with time pressures and high workloads.

- The procurement and design of arterial transducer line equipment, the pressure infusion bags and transducer, do not assist in the identification of the incorrect flush fluid or prevent contamination from the flush fluid of a blood sample taken

from the arterial line. Alternative equipment, for example transparent pressure infusion bags and closed arterial transducer lines, are currently available to the NHS. These may reduce the risk but are not routinely in use.

- Challenges in the provision of a consistent suitable workforce and high workloads have a detrimental effect on the safety controls currently relied upon to avoid or identify the risk of using the wrong flush fluid. Safety checks and training lack resilience to organisational pressures regularly experienced within critical care units.

- There can be a delay in identifying the contamination with glucose of an arterial line blood sample due to a normalisation and acceptance that critically ill patients may have altered blood glucose levels and require insulin treatment, and a perceived low risk associated with the use of a flush fluid.

- The design of systems to record and monitor information relevant to the arterial transducer line system and blood glucose levels do not easily alert staff to the potential use of the wrong flush fluid.

- Recommendations issued over the last 14 years by national safety bodies and professional healthcare organisations to address the safety of blood sampling associated with arterial lines have not been effectively implemented.

HSIB makes the following safety recommendations

The intention of this safety recommendation is to provide design guidance for manufacturers to manage the risk associated with fluid selection. All aspects of label design should be considered this recommendation is broader than the judicious use of colour as the approach to increasing label safety.

Safety recommendation R/2022/200:
HSIB recommends that the Medicines and Healthcare products Regulatory Agency [Head of Metabolic Disorders and Renal Systems] engages with other national regulators and relevant stakeholders to develop design guidance on labelling and packaging specific to fluids to reduce selection errors.

The intention of this safety recommendation is to ensure fluid labels can be consistently read from all directions at all times when the pressure infusion bag is inflated.

Safety recommendation R/2022/201:
HSIB recommends that the Medicines and Healthcare products Regulatory Agency [Head of Metabolic Disorders and Renal Systems] reviews and acts on the available evidence to regulate for the use of pressure infusion bags that allow fluid labels to be read when inflated.

The intention of this safety recommendation is to increase awareness of and action on known risks related to the design of the medical devices.

Safety recommendation R/2022/202:
HSIB recommends that the Medicines and Healthcare products Regulatory Agency [Head of Metabolic Disorders and Renal Systems] communicates to all relevant stakeholders and acts on the available evidence concerning the management of the risks associated with arterial transducer line sets.

The intention of this safety recommendation is to assure appropriate action is taken to manage the known risks related to the design of the medical devices.

Safety recommendation R/2022/203:
HSIB recommends that the Department of Health and Social Care [Director of Medical Technology], once post-market surveillance data is available, involves relevant stakeholders including the Association of Anaesthetists' review and determine appropriate actions that could be taken to further mitigate the risk of blood sample contamination by the flush fluid when using arterial transducer line systems.

The intention of this safety recommendation is for the Association of Anaesthetists to revise existing national guidance in collaboration with all relevant healthcare professionals including the following clinical areas: critical care, theatres and emergency departments.

Safety recommendation R/2022/204:
HSIB recommends that the Association of Anaesthetists [President] works with relevant professional organisations to revise existing national guidance to manage the risks of contamination by the flush fluid when using an arterial line to take a blood sample.

The intention of this safety recommendation is to provide assurance that NHS providers have implemented the future national guidance.

Safety recommendation R/2022/205:
HSIB recommends that the Care Quality Commission [Chief Executive] reviews the recommendations from the Association of Anaesthetists on how to manage the risks of contamination by the flush fluid when using an arterial transducer line and determines any appropriate actions for the oversight of governance and assurance arrangements within NHS providers following.

HSIB makes the following safety observations

Safety observation O/2022/179:
It may be beneficial to recognise that safety risks are not reliably reported and therefore that the likelihood and level of harm may not be accurately reflected through existing reporting systems.

Safety observation O/2022/180:
It may be beneficial to recognise that workload and fatigue will influence the reliability of safety controls dependent on staff time and attention.

Safety observation O/2022/181:
It may be beneficial, to undertake product essential specification development with end users as part of any NHS procurement framework renewal.

Safety observation O/2022/182:
It may be beneficial for future reviews of the design of storage space within critical care units to consider the engagement of expertise in physical workspace design.

Safety observation O/2022/183:
It may be beneficial to increase the speed of implementation of the use of technology to support closed-loop medicines administration systems.

Safety observation O/2022/184:
It may be beneficial to review the unintended consequences associated with the use of pre-populated prescriptions for arterial flush fluid and also insulin.

Safety observation O/2022/185:
It may be beneficial if regulatory bodies remain alert to and encourage the adoption of alternative approaches to continuous glucose monitoring.

Safety observation O/2022/186:
It may be beneficial to consider how the design processes and guidance for blood glucose recording can support identification and early warning of a potential blood sample contamination by flush fluid.

HSIB notes the following safety action

Safety action A/2022/053:
The Association of Anaesthetists has started to identify relevant stakeholders for the development of guidance on blood sampling when using arterial transducer line systems.

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Further information

More information about HSIB – including its team, investigations and history – is available at **www.hsib.org.uk**

If you would like to request an investigation then please read our **guidance** before contacting us.

@hsib_org is our Twitter handle. We use this feed to raise awareness of our work and to direct followers to our publications, news and events.

Contact us

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