Arterial line safety
Learning from a serious untoward incident on the Intensive Care Unit.

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Royal United Hospital
Bath
Specialist Nurse – Organ Donation
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20th June 2014
“Habit is the nursery of errors.”

Victor Hugo, French poet and novelist of the 1800’s.
Problems with infusions and sampling from arterial lines

Issue
Arterial lines are routinely used in critical care areas for sampling arterial blood to measure blood gases, glucose and electrolytes. Patients may be harmed if the wrong infusion is given to keep the line open or when poor sampling leads to delayed or inappropriate treatment.

Evidence of harm
The NPSA is aware of two deaths and 82 other incidents up to June 2008 where the wrong infusion fluid was attached to the arterial line. A further 76 incidents, including one case of serious harm, related to faulty sampling technique. High risk situations reported include sampling blood glucose from lines with glucose running (and patient treated based on falsely high readings) and mis-selecting potassium chloride instead of sodium chloride 0.9% for injection.

Contributing factors include look alike labelling and packaging of intravenous infusion bags and inadequate checking before attachment. A particular risk is the need to cover the infusion with a pressure bag which obscures the label during use. Risks of confusion are increased when patients are transferred from other areas. Sampling errors include problems when taking and managing the samples, contamination by inadequate flushing and confusing arterial with venous lines.

Scope
This guidance applies mainly to critical care, and other areas such as emergency departments where arterial lines are put up and managed.

Reducing risks
To minimise risks, clinical teams should ask themselves:
- Have I recorded the clinical reason for inserting this line? Is it clearly marked as an arterial line?
- Do I need to take this sample?
- Do I know how to do this safely (eg removing air from sample)?
- Have I picked the right infusion fluid bag? Did someone else check this?
- Can the label be seen, even if pressure bags are used?
- Is the reading from the sample within the expected range? Could it have been contaminated?

For IMMEDIATE ACTION by Medical and Nursing Directors in the NHS and the independent sector. The deadline date for ACTION COMPLETE is 30 January 2009.

Sampling from arterial lines is risky and should only be done by competent, trained staff. Trusts should raise awareness of risks and review local guidelines. These should include criteria for requests for blood gas analyses; sampling technique, monitoring and interpretation of results (including unexpected results). Arterial infusion lines must be clearly identified. This means labelling or use of other safety solutions such as marked lines adopted by some trusts (see supporting information).

Any infusion (or additive) attached to an arterial line must be prescribed and checked before administration. Further checks should be made at regular intervals and key points (such as shift handover). Staff should use only sodium chloride 0.9% to keep lines open.

Labels should clearly identify contents of infusion bags, even when pressure bags are used. Over time, manufacturers should develop a universal system to address this problem.

The NPSA has published a Design for Patient Safety Booklet on Injectable Medicines. NHS procurement groups should work with pharmaceutical manufacturers to develop and procure infusion bags following these guidelines.

The NPSA has informed:
All NHS organisations, the independent sector, commissioners, regulators and relevant professional bodies.

Further Information

Further queries to Linda Matthew, Senior Pharmacist or Tara Lamont, Head of Response.
Email: rm@npsa.nhs.uk Telephone 020 7927 9890.
Changes to practice in our unit following the 2008 NPSA alert

- A bedside guideline for the care of an arterial line and taking arterial blood gas samples.
- Introduction of arterial lines with red stripe and arterial line labels.
- Individual prescription for arterial lines, incorporated into pre-printed ICU drug charts.
Case Study

- Mr. S. is admitted to ICU with acute pancreatitis and multi-organ failure.
- Day 10 of admission sees an improvement and respiratory support weaned.
- Late on day 10, condition deteriorates requiring re-intubation.
- Arterial line fails after re-intubation, re-insertion proves difficult.
- Two days of instability, prevents a sedation hold.
- Day 13 – Condition stabilizes and sedation hold performed, however Mr. S. does not awake as previously.
Later that evening a discrepancy is noted between blood sugars.

Night staff change arterial line fluid and giving set and find error.

Chart review finds the bag had been in place for 72 hours.

Mr. S. remains unconscious, diagnosed with a hypoglycaemic brain injury.

Mr. S dies on day 20 of his admission never regaining consciousness.
Serious untoward incident investigation (SUI)
Appearance of arterial line fluid

A) When checked

B) Out of transducer bag
Sodium chloride with 5% dextrose introduced to the unit to manage paediatric emergencies

This bag is mistakenly placed in a store cupboard intended for 0.9% sodium chloride

Nurse collects this bag of fluid when collecting a bag of 0.9% sodium chloride from store

Double checking of arterial line fluid either does not occur or fails to detect mistake

Difficult and prolonged arterial line insertion

Wrong fluid bag is attached to the patient

Glucose contamination occurs – despite correct sampling technique causing spurious hyperglycemia

Insulin infusion commenced as per protocol

Normal shift-change arterial line checks thwarted by position of infusion in pressure bag

Recognition of decreased consciousness from hypoglycemia goes undetected by ongoing patient sedation

Undetected hypoglycemia causes neuroglycaemic brain injury
Action plan

Presented to HM Avon Coroner
## Ongoing Actions

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<td>If tracheostomy in place ensure tracheal dilators and appropriate size replacement tracheostomy tubes available at back of bed space.</td>
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<td>Check ventilator settings are correct. Ensure appropriate adult/pediatric mode, and that menus number is recorded on observation chart.</td>
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<td>Check anaesthesia ventilation is activated. Check trigger set on 2 L/min</td>
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<td>Ensure all disposables are changed, dated &amp; sterilised as per unit policy.</td>
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<td>Record Heart Rhythm on observation chart.</td>
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<td>Defibrio pressure bag and check 500mL NS sterile 0.9% flush is attached to arterial transducer. Reinfate where check pressure is equivalent to 300mmHg. Ensure line labelled and dated.</td>
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<td>Rezero all transducers in place.</td>
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<td>Record non-invasive blood pressure on both arms on admission and thereafter once daily on arterial line arm only.</td>
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<td>Check all intravenous drug infusions are correct according to prescription chart, labelled correctly and are compatible.</td>
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<td>Check medicine drawer contents for patient own drugs, sterile water and saline ampoules only. Keep drawer locked at all times.</td>
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<td>If insulin protocol/bedside scale in use check rate is correct. Identify which scale is in use on observation chart.</td>
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<td>Check position of all intravenous lines and VIP score as necessary.</td>
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<td>Check nasogastric tube lines, length and rate of feed and document on chart.</td>
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<td>Document insertion dates of all invasive lines, drains &amp; tubes on appropriate care plan/charts.</td>
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<td>Check declarafer completed on admission profile &amp; next of kin details correct.</td>
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### Print Name

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### References


### Version Information

- **Author:** A. Majielle
- **Ratified:** N. Boyland, J. Hunt
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- **Approved by Documentation Review group:** DRG 17

To be filed in patient notes
Action plan

(continued)

- Local Arterial line policy.
- Arterial line competency - 2yrly and on induction.
- Preceptorship program – TRAINING!
- Arterial line monograph.
- ICU specific orientation for agency staff.
- Daily electronic audit monitoring compliance of arterial lines and the safety checklist. (including prescribing and 2 nurse signing)
- Paediatric fluid stored in a locked cupboard.
Action plan

(Continued)

- Improved labeling of arterial lines.
- New cupboards for drug and fluid storage, no decanting of fluids from their boxes.
- Change to clear pressure bags to enable clear vision of the fluid inside.
- Changed protocol for commencing insulin, including a trigger to inform medical staff if BMs suddenly increase.
- Trust wide-education, learning from our experience.
- National sharing of our experience.
Case Report

Accidental hypoglycaemia caused by an arterial flush drug error: a case report and contributory causes analysis

K. J. Gupta and T. M. Cook

Consultants, Department of Anaesthesia and Intensive Care Medicine, Royal United Hospital, Bath, UK

Summary
In 2008, the National Patient Safety Agency (NPSA) issued a Rapid Response Report concerning problems with infusions and sampling from arterial lines. The risk of blood sample contamination from glucose-containing arterial line infusions was highlighted and changes in arterial line management were recommended. Despite this guidance, errors with arterial line infusions remain common. We report a case of severe hypoglycaemia and neuroglycopenia caused by glucose contamination of arterial line blood samples. This case occurred despite the implementation of the practice changes recommended in the 2008 NPSA alert. We report an analysis of the factors contributing to this incident using the Yorkshire Contributory Factors Framework. We discuss the nature of the errors that occurred and list the consequent changes in practice implemented on our unit to prevent recurrence of this incident, which go well beyond those recommended by the NPSA in 2008.

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Email: timcook007@googlemail.com
Accepted: 11 July 2013

Management of arterial lines and blood sampling in intensive care: a threat to patient safety

R. A. Lees,1 S. Gouldson,2 N. Habib,2 N. Harris,2 H. Murray,2 V. Wells2 and T. M. Cook4

1 Specialist Registrar, 2 Core Trainee, 3 Clinical Fellow, 4 Consultant, Department of Anaesthesia and Intensive Care Medicine, Royal United Hospital, Bath, UK

Summary
In 2008, the UK National Patient Safety Agency (NPSA) made recommendations for safe arterial line management. Following a patient safety incident in our intensive care unit (ICU), we surveyed current practice in arterial line management and determined whether these recommendations had been adopted. We contacted all 241 adult ICUs in the UK; 228 (94.6%) completed the survey. Some NPSA recommendations have been widely implemented, use of sodium chloride 0.9% as flush fluid, two-person checking of fluids before use and their practice was consistent. Others have been incompletely implemented and many areas of practice (prescription of fluids, two-person checking at shift changes, use of opaque pressure bags, arterial sampling technique) were highly variable. More importantly, the use of the wrong fluid as an arterial flush was reported by 30% of respondents to ICU practice, and a further 30% for practice elsewhere in the hospital. Our survey provides evidence of continuing risk to patients.

Correspondence to: T. M. Cook
Email: timcook007@googlemail.com
Accepted: 11 July 2013

In critically ill patients, indwelling arterial canulae are routinely inserted for continuous blood pressure monitoring and to obtain arterial blood samples for blood gas, glucose and electrolyte analysis. However, these arterial canulae are not without risk. In 2008, the UK National Patient Safety Agency (NPSA) published a Rapid Response Report about a patient who died of sepsis. This patient had an arterial canula inserted for arterial line sampling. The arterial canula had been inserted into the femoral artery, which was not the intended insertion site. The arterial canula had been inserted into the common femoral vein, which is not an arterial vein. A search of the National Reporting and Learning System (NRLS) in the three years after the 2008 NPSA alert identified 169 further reports of arterial line drug errors (Prof. D Cousins, Senior Head of Patient Safety for Safe Medication Practice and Medical Devices, NHS England, personal communication). This is one per week, on average. Almost one third of patients with arterial line drug errors were found to have glucose-containing fluids, with glucose 5% being the most common incorrect fluid. In a recent national survey of practice, more than 30% of UK intensive care units (ICUs) reported arterial line infusion errors, with a further 30% reporting errors in their hospital outside the ICU (4). In both settings, glucose-containing fluids were most frequently involved. These data imply that arterial line infusion errors remain a large-scale national problem, despite the practice recommendations made in the 2008 NPSA report. We report a further case of severe hypoglycaemia and neuroglycopenia brain injury caused by glucose contamination of arterial line blood samples. This case occurred despite full implementation of the practice changes recommended in the 2008 NPSA report. We analyse the factors contributing to this incident using glucose values in arterial line samples and subsequent inappropriate insulin administration, causing severe hypoglycaemia, neuroglycopenia and irreversible brain injury. A further analysis by the NPSA after their 2008 alert (Jolly 2008 to May 2011) identified another 169 reports where the wrong infusion fluid was attached to arterial lines (Prof. D Cousins, Senior Head of Patient Safety for Safe Medication Practice and Medical Devices, NHS England, personal communication) (Table 1). Glucose 5% accounted for 29.0% of these errors. In total, glucose-containing solutions accounted for the wrong infusion fluid in 192 (60.4%) errors: 30 (39.4%) reports were where a glucose-containing fluid was used included a glucose monitoring error. The 2008 NPSA Rapid Response Report made several recommendations for avoiding these errors (Table 2).
UK Telephone survey
Management of arterial lines and blood sampling

241 ICU’s - 228 agreed to take part.
8.7% had heard of the NPSA 2008 rapid response alert
82.5% - had a written policy.
72.4% - stated arterial line flush fluid was prescribed by a Dr.
27.6% of units said arterial line fluid was NOT prescribed.
7.5% of units routinely removed the fluid from the pressure bag to check its contents.
30.3% were aware of arterial line errors in their unit.
14.5% of all described errors cited 5% dextrose as the incorrect fluid.
What volume of blood do you discard prior to taking ABG?
- 73.4% of units took 2-5mls  <2mls in 9.2%
- 69.3% stated discard volume was consistent on their unit.

Why this volume?
- 47.2% to ‘clear the line’ or ‘clear the dead space’.
- 50% unsure as why this volume of fluid discarded.

Of those who mentioned ‘clear line’ or ‘dead space’.
- 39.8% knew the dead-space for their system

Of these, 22% withdrew and discarded >3Xs the dead-space of their system.
As part of the coroners recommendations and verdict -

Guidelines written by Anaesthetists of Association of Great Britain and Ireland.

‘Arterial line blood sampling: preventing hypoglycaemic brain injury 2014’

Guidelines

Arterial line blood sampling: preventing hypoglycaemic brain injury 2014

The Association of Anaesthetists of Great Britain and Ireland

Membership of the Working Party: T. E. Woodcock, T. M. Cook, K. J. Gupta and A. Hartle

Summary
Drawing samples from an indwelling arterial line is the method of choice for frequent blood analysis in adult critical care areas. Sodium chloride 0.9% is the recommended flush solution for maintaining the patency of arterial catheters, but it is easy to confuse with glucose-containing bags on rapid visual examination. The unintentional use of a glucose-containing solution has resulted in artefactually high glucose concentrations in blood samples drawn from the arterial line, leading to insulin administration causing hypoglycaemia and fatal neuroglycopenic brain injury. Recent data show that it remains a common error for incorrect fluids to be administered as arterial line flush infusions. Adherence to the National Patient Safety Agency’s 2008 Rapid Response Report on this topic may not be enough to prevent such errors. This guideline makes detailed recommendations on the prescription, checking and administration of arterial line infusions in adult practice. We also make recommendations about storage, arterial pressure monitoring and sampling systems and techniques. Finally, we make recommendations about glucose monitoring and insulin administration. It is intended that adherence to these guidelines will reduce the frequency of sample contamination errors in arterial line use and capture events, when they do occur, before they cause patient harm.

This is a consensus document produced by expert members of a Sprint Working Party established by the Association of Anaesthetists of Great Britain and Ireland (AAGBI). It has been seen and approved by the AAGBI Board. Accepted: 5 November 2013

- What other guideline statements are available on this topic?
  In July 2008, a National Patient Safety Agency (NPSA) Rapid Response Report was released [1], highlighting examples of patient harm resulting from glucose-containing flush infusions contaminating blood samples drawn from arterial lines [2, 3]. Subsequently, it was reported to the Safe Anaesthesia Liaison Group in 2011 that the NPSA had received 169 further incident reports, featuring 31 glucose monitoring errors (personal communication, Prof. D. Cousins, NHS England). The Medicines and Healthcare products Regulatory Authority (MHRA) issued a Drug Safety Update on the issue in 2012 [4].
- Why was this guideline developed?
  Experiment and experience show that compliance with the procedures required in the NPSA’s 2008 Rapid Response Report, even with good sampling technique using a simple open arterial line system, is not sufficient to prevent injury or death arising from sample contamination error. In a series of 102 cases where a glucose-containing solution was incorrectly
To err is human and to honestly learn from clinical error is an absolute need for the medic.

Julian Hopkin