NHS
National Patient Safety Agency

Rapid Response Report

PSA/2008/RRR006

From reporting to learning

28 July 2008

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
Supporting information on this Rapid Response Report: http://www.npsa.nhs.uk/patientsafety/alerts-and-directives/rapidrr/
Further queries to Linda Matthew, Senior Pharmacist or Tara Lamont, Head of Response,
Email: rrr@npsa.nhs.uk Telephone 020 7927 9890.

National Patient Safety Agency

SUPPORTING INFORMATION

for

RAPID RESPONSE REPORT NPSA/2008/RRR06

Problems with infusions and sampling from arterial lines

28 July 2008

Background

Arterial lines are routinely used in critical care areas to obtain samples of arterial blood, to test for blood gases, glucose and electrolytes. Slow infusions of sodium chloride or heparinised saline are currently used to keep the arterial line open.

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.

A recent study showed that in one surgical intensive care unit, as many as 46,000 arterial blood gas analyses were performed each year. Audit showed that over half of these tests could not be justified clinically and the vast majority (96%) of requests were left to the discretion of nursing staff (Merlani et al, 2001).

The NPSA is aware of two deaths and 82 other incidents up to June 2008 where the wrong kind of infusion has been attached to the arterial line. A further 76 incidents, including one case where a patient suffered serious harm, related to poor sampling technique or practice. The most recent patient death resulted from an infusion of glucose/saline being wrongly selected and a contaminated sample leading to artificially high readings of blood glucose levels and a resulting overdose of intravenous insulin. The patient sustained severe brain damage and died shortly after.

We have received many reports relating to the confusion of infusion fluids. These include examples of antibiotics, glucose, dextrose, insulin and potassium chloride being wrongly selected. Contributing factors include look-alike labelling and packaging of intravenous infusion fluids, inadequate checking of infusion bags before administering to patients and the use of arterial pressure bag on infusion bags which can obscure labels during use.

Reports relating to sampling highlighted problems in taking and managing the samples, contamination of samples by infusates, arterial line infections, confusion of arterial and venous lines, availability and use of blood gas analysers and staff training. Training should be competency based and include all issues of infection control and of management of the samples (e.g. removing air from blood gas sample). Training should focus on pre-procedure checks, competence in taking samples, and careful management of samples to exclude contamination and inaccurate results.

Review of evidence of harm

National Reporting & Learning System (NRLS)

Interpretation of data from the NRLS should be undertaken with caution. As with any voluntary reporting system, the data are subject to bias. A proportion of incidents which occur are not reported, and those which are reported may be incomplete having been reported immediately and before the patient outcome is known.

Two pieces of analysis were carried out relating to a) misidentification of infusions for arterial lines and b) problems with arterial line sampling.

a) Mis-identification of infusions for arterial lines

A search was performed on incidents in the NRLS for incidents involving misidentification of infusions for arterial lines. As at 18 June 2008, 84 incidents were found relating to the search[1].

[1]The NRLS was established in October 2003 and all NHS organisations were able to report to the NRLS by 1 January 2005. It is important to note the volume of reports received by the NRLS has steadily increased since inception, and as the NRLS is a voluntary reporting system, the data may not be representative of the rates of incidents across England and Wales.

Table one summarises the reported degree of harm to the patient(s) for these incidents. While the majority of these patient safety incidents resulted in no harm (71%), two incidents resulted in death (2%).

Table 1: Patient safety incidents involving misidentification of infusions for arterial lines by degree of harm

Base: All incidents in the NRLS involving misidentification, as at 18 June 2008

Degree of harm	Incidents	Percent
No Harm	60	71
Low	18	21
Moderate	4	5
Severe	0	0
Death	2	2
Total	**84**	**100**

Note: Incidents reporting severe harm or death have been reviewed and re-coded where appropriate

Table two provides details of the infusion type that emerged from review of the reports describing incidents involving misidentification of infusions for arterial lines.

Table 2: Patient safety incidents involving misidentification of infusions for arterial lines by infusion type

Base: All incidents in the NRLS involving misidentification, as at 18 June 2008

Wrong Medicines	Incidents
Glucose 5%	19
Glucose/saline	16
Hartmans	10
Heparinised saline	9
Sodium chloride 0.9% and potassium	6
Sodium chloride 0.9%	6
Mannitol	2
Glucose/saline with potassium	1
Sodium chloride 0.45%	1
Sodium chloride 0.45% & heparin	2
Dextran	1
Antibiotics	1
X-ray contrast media	1
Glucose 10%	1
Glucose 10% and potassium	2
Glucose 10% and sodium chloride and potassium	1
Glucose 50%	1
Heparin	1
Insulin	1
Potassium concentrate	1
Water for injection	1
Total	**84**

Misidentification of infusions for arterial lines - example reports

Death resulting from mis-selection of glucose 5% infusion

85 year old female in ICU for 3 weeks, ventilated and recovering from multiple organ failure after emergency laparotomy for perforated colon. Patient became suddenly unconscious about 1pm.
No improvement by 5pm and so CT scan requested. Presumption was she had had a stroke. Had been on prophylactic Fragmin - suspicion of cerebral haemorrhage. CT done at 1745 - normal.

Laboratory blood glucose result at 1900 showed blood sugar to be 0.1mmol/litre. Immediately, IV glucose given and insulin stopped (had been stopped on trip to CT as well).

The patient suffered neuroglycopenic brain damage and remained comatose.

During the afternoon in question, blood glucose on ICU machine samples had been rising and so insulin infusion had been increased. Despite this, blood sugars remained 8 -10 mmol/litre. Hence insulin infusion continued at 6 - 8 units / hour to attempt to maintain normoglycaemia. It subsequently transpired that the flush solution in the arterial line pressure bag was accidentally changed to 5% glucose instead of the prescribed normal saline.

However as all the blood samples for blood glucose were taken from the arterial line (and measured in the ICU blood gas machine) it appears that the samples were contaminated with glucose and erroneously appeared high. At one stage, a BM finger prick blood glucose test was done. However, the machine read 'LOW' and did not give a numeric reading. The SHO and nurse interpreted this as a faulty machine as a value was not displayed. Also, as the blood glucose results from the arterial line were all consistently higher, the BM machine result was disregarded. Additionally, in the last year we have withdrawn our BM glucose machines on the biochemistry dept advice as QA issues were raised as part of POCT (point of care testing) review. Our new blood gas machine has the facility for blood glucose measurement and so this is routinely used and the BM machines are not used and staff not fully trained in their use any more .

Moderate harm as a result of mis-selecting potassium chloride concentrate infusion
Arterial line pressure increasing, went to check site and cause. Found 22mls of potassium chloride concentrate infusion 40mmol / 100ml had been infused via the flush system hub. Aspirated 20mls and flushed with saline, elevated on pillows. Vascular observations documented at time. Reddened area noted and marked. Bruising on top of hand. Pulses present.

Low harm as a result of mis-selecting glucose 50% infusion
Routine arterial blood gas taken from arterial line, line flushed post sample. Patient reported severe burning pain at arterial site and tracking up right arm. Noted bruising up arm. Hand very red. Checked flush system. Noted 50% glucose flushing via arterial line. Stopped immediately on inspection found storage box filled with glucose 50% bags rather than sodium chloride 0.9% 500ml bags . All other flush bags checked and no other incident / incorrect bag noted .

Low harm as a result of mis-selecting sodium chloride and potassium infusion
Patient had been complaining that the arterial line was burning and stinging when used during the day particularly when flushed, this is not normal with an arterial line. The flush bag attached from A&E was found to be sodium chloride 0.9% with 20mmols potassium.

Low harm as a result of mis-selecting x-ray contrast media
On return from MRI scan, attempted to aspirate patients arterial line to gain blood sample at which point patient informed me that the x-ray contrast in MRI was given through arterial line. I stopped trying to aspirate line and informed Doctor who assessed patient and made patient aware of what had happened. Staff nurse had bunged off the arterial line before the MRI scan and another staff nurse who had escorted patient to the MRI department was unaware of line being an arterial line. MRI staff who administered contrast also unaware line was arterial. Regular observation of patients' affected hand.

No harm as a result of mis-selecting insulin infusion
While on the ward round it was indicated to the doctor that the arterial line wasn't working properly. Doctor assessed the situation and found the sliding scale insulin infusion had been attached to the arterial line. Doctor flushed the line with normal saline. Some bleeding noted. The mix-up happened when changing the patient gown.

b) Problems with arterial line sampling

A search was performed on incidents in the NRLS where the reported care setting was 'Acute / general hospital' for incidents involving arterial line sampling. As at 18 June 2008, 76 incidents were found relating to poor sampling technique or practice.

These relate to poor sampling technique (e.g. failing to remove air from a sample); problems in accessing equipment or interpreting results; confusing arterial with venous lines; handling and managing the samples, including infection control risks; and problems in positioning and anatomical placement of lines.

Table three summarises the reported degree of harm to the patient(s) for these incidents. While the majority of these patient safety incidents resulted in no harm (79%), one incident resulted in severe harm (1%).

Table 3. Patient safety incidents related to poor sampling technique or practice by degree of harm
Base: All incidents in the NRLS involving poor sampling technique in the acute/general hospital setting, as at 18 June 2008

Degree of harm	Incidents	Percent
No Harm	60	79
Moderate	8	11
Low	7	9
Severe	1	1
Death	0	0
Total	**76**	**100**

Note: Incidents reporting severe harm or death have been reviewed and re-coded where appropriate

Problems with arterial line sampling – example reports

I obtained a blood sample from venflon in back of patients' right wrist to check potassium level as patient was receiving treatment for hyperleukaemia. The blood was analysed on ITU ABG machine. On reviewing the results it was evident that the venflon was in an artery and not a vein. Patient had received drugs and fluids through this line.

Haemofiltration, sodium bicarbonate and heparin commenced via subclavian vascath. Blood appeared very red, ' blood gas analysis revealed an arterial sample. Heparin and sodium bicarbonate stopped immediately and anaesthetic SHO contacted who advised the consultant on call and haemofiltration was stopped .

On call for Clinical Chemistry was called by a nurse on HDU for advice on the gas machine. On arrival on HDU a doctor from a ward other then HDU / ITU was attempting to use the machine although it clearly had error messages and was not working. Unidentified member of staff used inappropriate sample and broke analyser. Was concerned at the lack of training for doctors in the hospital for sampling of blood gases and use of blood gas machines as clearly illustrated in this incident .

Difficulty in finding a working ABG machine in emergency. My assistant found ITU had been restoring parameters on the blood gas analyser when they had been locked due to a quality control sample failure. No corrective action had been taken and the quality control was not repeated. Wrong results which could be used to treat the patient.

Arterial blood gas requested brought to ICU by {Staff member} not wearing gloves sample not in receptacle, no ice present, filter cap not used, excess air not expelled. Contrary to trust policy re blood gas monitoring and infection control.

Literature search

A full literature search (see below) was undertaken as well as an internet search and site searches of key international patient safety sites were made. Guidelines on the management of arterial lines and case reports were traced, but no systematic reviews.

Literature search revealed papers on related issues, such as excessive blood loss through arterial sampling (O'Hare & Chilvers, 2001) and inappropriate requests for blood gas analysis in intensive care (Merlani, P. et al, 2001).

Directly relevant papers on confusion of infusion bags included:

- Case report (Bates, 2002): accidental substitution of insulin for heparin flush, leading to the patient's death. Factors implicated: poor drugs storage, no drug counter-checking system, delay in suspecting drug error.

- Case report (Sinha, Jayaram & Hargreaves, 2007) reported use of glucose 5% instead of saline to clear occluded line, leading to contamination of the blood sample with glucose, increase in insulin dosage, and subsequent fatal hypoglycaemia. Factors implicated: failure to discard sufficient blood from the line, failure to act on conflicting results from two glucose reading devices, delay in suspecting drug error.

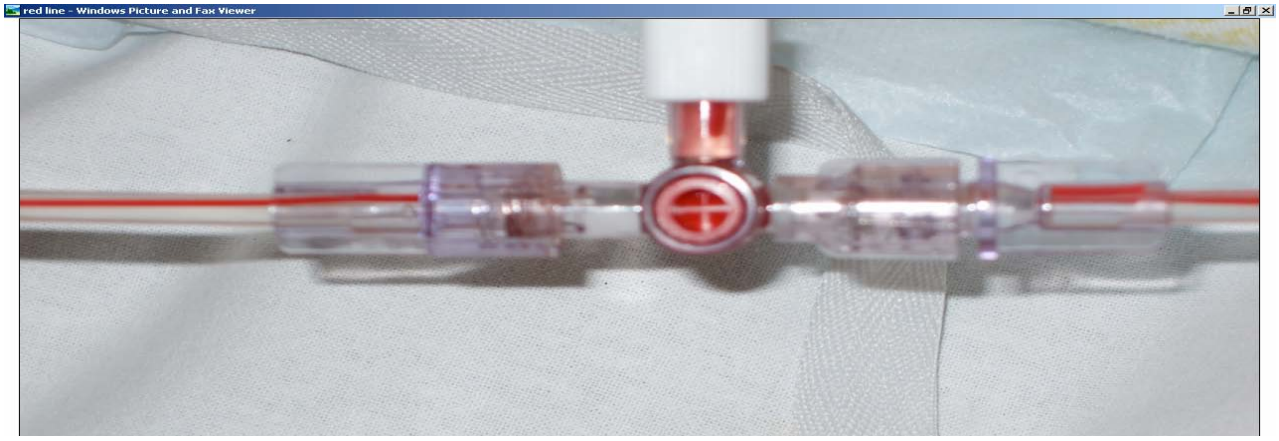
- Panchaganula & Thomas (2007) use analysis of NRLS data cited in this paper to highlight the problems of selecting the wrong arterial line flush solution.

Search terms: Medline (1950-) and Embase (1974-) were searched using MESH, Embase thesaurus and free text terms, singly and in combination: Arterial line; sampl$1, sampling, fluid bag$1, saline, glucose, flush, bag, tub$3, intensive care, blood sampling, adverse event, medical error, harm, death, contamination.

Further information

There is no evidence base on the effectiveness of different strategies to reduce risks from arterial line sampling. In the longer term, manufacturers need to test and develop universal solutions to minimise the risks outlined in the Rapid Response Report.

One key imperative is for arterial lines to be clearly identifiable as such at all times. Staff can achieve this through a system of labelling, including colour labelling. Some trusts use arterial lines that have a continuous coloured line running through to prevent confusion with venous lines, as illustrated below.



Conclusions

The NPSA is aware of a number of reports of serious harm and deaths arising from errors from confusion of fluid bags and poor sampling from arterial lines. The Rapid Response Report highlights some actions which can be taken to minimise risks by raising awareness of staff, training and local systems to identify lines and infusates, check fluids and monitor patients. Longer term design solutions are needed to address some of these risks but there are some immediate actions which can be taken to reduce risks to patients.

References

Bates, D. W. (2002). Unexpected hypoglycemia in a critically ill patient. **Annals of Internal Medicine 2002; 137(2),** 110-116.

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O'Hare, D & Chilvers, R.J. (2001). Arterial blood sampling practices in intensive care units in England and Wales. **Anaesthesia 2001; 56:** 568-584.

Panchaganula, U. & Thomas, A.N. (2007). The wrong arterial line flush solution. **Anaesthesia 2007**; **62:** 1075-1081.

Sinha, S., Jayaram, R. & Hargreaves, C.G. (2007) Fatal neuroglycopaenia after accidental use of a glucose 5% solution in a peripheral arterial cannula flush system. **Anaesthesia 2007; 62,** 615-620.