



Nursing Management of Arterial catheters for Critically Ill Patients

Arterial Guideline Development Network

NSWHealth Statewide Guidelines for Intensive Care



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<p>Disclaimer</p> <p>This clinical practice guideline (CPG) is aimed at providing the clinicians of NSW intensive care units (ICU) with recommendations to frame the development of policies and procedures related to 'Care of an arterial catheter (post insertion) in critically ill adults'.</p> <p>This CPG is a distillation of several processes: an integrative review of the literature (available up to December 2006); an evaluation of how this literature applies to the NSW intensive care context; the extensive clinical knowledge of the guideline development network members (GDN); and a consensus development process.</p> <p>The CPG is not intended to replace the critical evaluation processes that underpin the development of local policy and procedure nor a clinician's judgment in an individual case.</p> <p>Users of this CPG must critically evaluate this CPG as it relates to local circumstances and any changes in the literature that may have occurred since the dates of the literature review. In addition NSWHealth clinicians must review NSW state government policy documents to identify any directives that may relate to this clinical practice.</p> <p>These guidelines will be updated every 3 years.</p> <p>These guidelines are intended for use in adults only.</p> <p>NSW Health holds copyright of this CPG. No permission is given to redistribute, publish or commercialise this material in any way. The user agrees that in the event that part of the material in this CPG is reproduced or quoted, either in whole or in part, that the copyright owners' name and interest in the matter will be acknowledged.</p> <p>Permission MUST be granted to publish this CPG as a stand-alone document on a website other than those of NSWHealth. This permission may be obtained by contacting NSW Intensive Care Coordination and Monitoring Unit (ICCMU). Phone: 61 2 4734 1585 - FAX : 61 2 4734 1586 – Email: iccmu@wahs.nsw.gov.au</p>		

Index

Executive Summary	5
Clinical Practice Guideline	8
1. Introduction	8
2. Scope	8
3. Purpose	8
4. Target Clinicians	9
5. How the guideline was developed	9
6. How to use guideline	9
7. Format of guideline.....	9
8. Level of Evidence taxonomy and how consensus opinion was developed.....	9
9. Infection Control.....	10
10. Occupational Health and Safety	10
11. Academic Facilitators	10
Recommendations for Practice	12
Process of Guideline Development.....	19
1. Description of Consensus development process	21
2. Guideline construction.....	22
3. External Validation Process.....	22
Integrative Literature Review	24
1. Introduction	24
2. Literature Search Protocol	24
3. Literature Review Process	25
4. Literature Synthesis Process	25
5. Taxonomy for level of evidence and grade of recommendation.....	25
6. Description of Literature identified	27
Appendix 1 – Data Extraction Tools.....	38
Appendix 2 - Survey ~ Arterial Catheter & Line Practice	40
References	42
<u>Tables</u>	
Table 1: NHMRC Grading of Recommendations (GOR)	6
Table 2: Recommendations for Practice	7
Table 3: Arterial Catheter - External Validation Panel Members	23
Table 4: EVP Consensus Results	23
Table 5: NHRMC Designations of Levels of Evidence	26
Table 6: NHMRC Grading of Recommendations	26
Table 7: Summary Tables of Research Papers included	28
Table 8: Summary Table of Research Papers not included.....	37

Abbreviations and Acronyms

CI	Confidence interval
CNC	Clinical Nurse Consultant
CNE	Clinical Nurse Specialist
CONSORT	Consolidated Standards of Reporting Trials http://www.consort-statement.org/?o=1001
CPG	Clinical Practice Guideline
ETT	Endotracheal tube
EVP	External Validation Panel
GCS	Glasgow Coma Scale
GDN	Guideline Development Network
GOR	Grading of Recommendations
HDU	High Dependency Unit
ICC	Intensive Care Collaborative
ICC-CDC	Intensive Care Collaborative – Consensus Development Conference
ICCMU	NSW Intensive Care Coordination and Monitoring Unit
ICU	Intensive Care Unit
NHMRC	National Health and Medical Research Council
OR	Odds Ratio
PICO	Population Intervention Comparison Outcome
PTS	Pressure Transducer System
RCT	Randomised Control Trial
SR	Systematic Review

Executive Summary

The purpose of this review was to investigate and appraise the research evidence pertaining to the management of arterial line monitoring systems in order to formulate clinical recommendations that could be used to develop unit specific clinical guidelines, protocols, and procedures for managing critically ill patients with arterial lines.

Using the PICO model, the review sought to find studies that included the following criteria: the population of interest was adults in a critical care unit with an arterial line; study interventions that addressed changing transducers, dressing procedures, continuous flush solutions, methods of securing lines to prevent dislodgement, frequency of line changes and methods of maintaining line patency; with outcome measures including absence of infection, line dislodgement, line patency and local or catheter related blood stream infections (CRBSI).

Key words (arterial, pressure, transducer, flush solution, dressing, line security, insertion site, suturing and splinting) in various combinations were used to search the Clinical Information Access Program (CIAP) databases such as CINAHL and Medline, Pubmed, Google and Google Scholar databases. Individual search strategies were developed by Arterial GDN members who focused on specific areas of arterial line management, such as dressings or frequency of line changes, searching databases between 1985 and 2005 and limiting the search to studies published in English language only. Other limitations of the search process were that sources of unpublished research were not accessed, use of search filters was limited and not all reference lists were checked for additional studies related to the GDN focus.

Single reviewers, using a checklist developed by the project coordinator and lead academic, critically appraised the literature for methodological quality. At a consensus development conference the Arterial GDN group collectively graded each paper according to the National Health and Medical Research Council (NHMRC) intervention grading criteria. The body of evidence pertaining to each area of arterial line management topic, such as frequency of line changes, were assessed according to the NHMRC body of evidence matrix and recommendation statements were formulated. A vote to attain consensus was then undertaken by ballot on the 'wording' of the recommendation statement using a 9-point Likert scale. If a median score of 7 was not reached then the statement was discussed, refined further and a second round of voting was conducted (this only occurred once in the Arterial GDN). In addition two recommendations were developed post ICC CDC using a

single postal round to reach consensus. Based on the body of evidence used to formulate the recommendation, each statement was graded according to NHMRC criteria below.

The review has highlighted the lack of quality evidence in this area. Although the search strategy did identify papers that on preliminary review appeared to meet the inclusion criteria, some papers were rejected due to deficiencies in study design or insufficient reporting of study design details. Of those papers that were included, several were not considered to be of an acceptable methodological quality on which to base high level clinical recommendations. As such, the recommendations are primarily based on consensus opinion of the Arterial GDN members; the findings of the arterial line survey conducted with 28 out of 43 New South Wales Intensive Care Units (ICUs) and limited published research. Consequently, these recommendations are based on a weak body of evidence and should be applied with some caution.

Table 1: NHMRC Grading of Recommendations (GOR)

Grade of recommendation	Description
A	Body of evidence can be trusted to guide practice
B	Body of evidence can be trusted to guide practice in most situations
C	Body of evidence provides some support for recommendation(s) but care should be taken in its application
D	Body of evidence is weak and recommendation must be applied with caution
Consensus Opinion	Where no evidence could be applied consensus opinion developed by: <ol style="list-style-type: none"> 1. Formulation of recommendation through discussion 2. Assignment of agreement by individual participants (Likert 1-9) 3. Consensus set at median of 7

Table 2: Recommendations for Practice

Number	Statement	Level of Evidence
1	Arterial catheter dressings should be transparent and occlusive.	Consensus Opinion
2a	Arterial catheter transducer sets should be changed every 96 hours.	D
2b	Arterial line flush bags should be changed as necessary and at a maximum of 96 hours (in conjunction with line/transducer changes).	D
2c	Arterial catheter dressings should be changed as necessary and at a maximum of 96 hours (in conjunction with line/transducer changes).	D
2d	Arterial catheter insertion site should be assessed for signs of local infection and catheter integrity hourly and when arterial line dressings are changed.	Consensus opinion
3	Normal saline should be used as the continuous flush solution to maintain arterial line patency.	D
4	The circulation of the limb distal to the arterial line insertion site should be assessed at least hourly.	Consensus opinion
5	Arterial catheters and transducer lines must be secured to prevent dislodgment or disconnection.	Consensus opinion
6	Closed pressure transducer sets should be used where possible to prevent patient infection and iatrogenic anaemia and clinician infection.	Consensus opinion

Clinical Practice Guideline

1. Introduction

Arterial catheters are frequently used in intensive care to both monitor a patient's blood pressure on a continuous basis and to provide easy access for frequent blood sampling. A number of different arteries are used, however, the radial artery remains the most commonly used artery. Arterial catheters and associated pressure transducer systems (PTS) are not without a number of potential complications including: local and blood stream infection; damage to the artery, reduction of blood flow to tissues distal to the insertion site; thrombophlebitis; embolus; aneurysm; and haemorrhage. The recommendations for practice contained in this guideline are provided to guide the development of local policy regarding care of a patient with an arterial line. However, these recommendations may not address all issues related to this practice for any single intensive care unit.

2. Scope

This guideline addresses issues related to the nursing care of an arterial catheter after insertion including: dressing type and frequency; security of the arterial catheter and transducer lines; the fluid used to maintain patency and frequency of changing the flask; type of transducer lines; and assessment of catheter and insertion site integrity. It does not address issues related to blood pressure assessment or insertion issues such as choice of artery, completion of an Allen's test or catheter selection. For recommendations related to antiseptic agent the guideline reader is referred to the CVC guideline. In addition the following issues although considered important are beyond the scope of this guideline:

- a. Issues related to patient autonomy such as patient consent and explanation of procedure.
- b. Completion of the sterile aspects of the practice using an aseptic technique.
- c. Documentation of patient assessment and outcomes of nursing procedures.

3. Purpose

This guideline has been developed to provide intensive care clinicians with recommendations to guide the development of local policy/procedures related to the management of arterial catheters and pressure transducer lines.

4. Target Clinicians

This guideline is for the use of all intensive care clinicians. This guideline will also be useful for any clinician who is responsible for the care of any patient with an arterial catheter insitu. It is assumed that users of this guideline have knowledge of anatomy and physiology related to arteries.

5. How the guideline was developed

This guideline was developed by the Arterial Guideline Development Network (GDN) comprised of senior nursing clinicians and academics with the ICCMU Intensive Care Collaborative project (see pages 18-21 for explanation of this process).

6. How to use guideline

This guideline is provided as a tool to inform the development of local practice polices in NSW intensive care units. It should be used in conjunction with other processes normally used to develop practice guidelines that can include: local audit of practice and outcomes; review of relevant literature and reference to other practice guidelines. Whilst a concerted effort was made to include relevant literature, other studies may have been published since this guideline was written and these should be identified, reviewed and considered for inclusion. Therefore the guideline should be critically evaluated like all identified literature.

7. Format of guideline

The Guideline is presented in three main sections:

Section 1 includes the recommendation statements and supporting narrative.

Section 2 is a detailed explanation of the Guideline development process.

Section 3 contains the integrative literature review.

8. Level of Evidence taxonomy and how consensus opinion was developed

The Australian NHRMC (NHMRC 2005) levels of evidence and grades of recommendations were used. Where suitable research evidence was not available the GDN members, from their clinical experience and the NSW survey of practice, formulated a recommendation. This recommendation was then voted upon using a 1-9 Likert scale and consensus was set as a median of 7.

9. Infection Control

Prevention of infection is an important aspect of any clinical practice and guideline users are directed to NSWHealth Policy directive (PD2007_036) and local policy to identify the infection control elements of this clinical practice. This includes but is not limited to: use of personal protective equipment, hand hygiene, disposal of equipment and medical waste and isolation of infectious patients. Areas of particular note include:

- a. 2.1 Standard Precautions
- b. 2.2 Additional Precautions
- c. 5.4 Blood and body substance spills
- d. 7.7.1 Intravascular access

10. Occupational Health and Safety

Guideline users are directed to local policy and procedures related to occupational health and safety to ensure operator safety whilst completing procedures.

11. Academic Facilitators

The Academic facilitators were identified through professional networks and were not paid to participate in the ICC project however ICCMU paid the costs of travel and accommodation for the ICC-CDC. Apart from Professor Elliott the other academic facilitators did not join the ICC project until June 2006. Five meetings were held, four by teleconference and one the day prior to the ICC-CDC. Tasks completed during these meetings included:

- a. Assignment to a particular GDN
- b. Discussion regarding the most appropriate levels of evidence and recommendation taxonomy
- c. Format of the consensus conference (ICC-CDC)
- d. Process of developing recommendations and reaching consensus
- e. Process for writing guidelines and peer reviewed publications.

Convenor, Academic Facilitators	Professor Doug Elliott Director of Research, Faculty of Nursing, Midwifery and Health University of Technology Sydney
Oral Care GDN	Associate Professor Patricia Davidson Professor of Cardiovascular and Chronic Care School of Nursing and Midwifery Curtin University of Technology
Eye Care GDN	Ms Andrea Marshall Sesqui Senior Lecturer in Critical Care Faculty of Nursing and Midwifery The University of Sydney
Suction of an artificial airway GDN	Dr Bridie Kent Director of Clinical Nursing Research School of Nursing - Faculty of Medical and Health Sciences University of Auckland
	Professor Wendy Chaboyer Director, Research Centre for Practice Innovation Griffith University Queensland
Stabilisation of an endotracheal tube GDN	Associate Professor Anne Gardner Professor, School of Nursing, Midwifery and Nutrition, James Cook University
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Arterial catheter GDN (nursing management)	Dr Tina Jones Manager, Australian Centre for Evidence Based Clinical Practice, Flinders Medical Centre Senior Lecturer, Faculty of Health Sciences, Flinders University
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Recommendations for Practice

Number	Statement	Grade of recommendation
1	Arterial catheter dressings should be transparent and occlusive.	Consensus opinion

Assessment of body of evidence: D – Poor

In order to be able to assess the arterial catheter insertion site for infection and ensure the catheter is secure and the potential for dislodgement is minimised, the dressing needs to be transparent and occlusive. Additionally, this dressing should cover the entire length of the catheter and include the luer connection where the transducer line attaches. The transparent dressing should have moisture permeability characteristics to minimise growth of microflora. There was limited relevant literature in relation to the type of dressing that should be used. A single centre randomised control trial (n=60) compared two dressing techniques (povidone skin preparation with a gauze dressing or a transparent dressing with 'IV prep' skin preparation) and found no differences in the complication rates between these two techniques. However methodological problems including inclusion criteria, randomisation method and set criteria for 'complications' limit the application of this finding (Gabel-Hughes and Geelhoed 1990). Another study comparing bacterial growth under gauze, transparent film and plastic wrap (Aly et al. 1988) found no difference between the growth of normal flora under the gauze and a commercial transparent dressing. However this was conducted with healthy subjects and the application of these findings to the critically ill population is limited. As there is no research specifically related to arterial catheter dressing management this recommendation is based primarily on the consensus opinion of those GDN clinicians involved in the ICCMU project and from an arterial catheter survey of NSW ICUs (where 26/28 ICUs used a transparent dressing). The EVP supported this recommendation (median 9, range 3-9).

Number	Statement	Grade of recommendation
2a	Arterial catheter transducer sets should be changed every 96 hours.	D

Assessment of body of evidence: D – Poor

The literature was assessed to determine how frequently the arterial line transducers needed to be changed to prevent catheter related infections. Catheter related infection in critically ill patients was addressed in the literature reviewed by the arterial GDN, however, one study did not specifically relate to the frequency of arterial line transducers sets but to catheter

related local and blood stream infection (Lorente et al. 2004). Although a dated study Luskin et al (1986) conducted a prospective RCT which compared line changes at 2, 4 and 8 days, and found it was safe to extend arterial catheter transducer set changes to 4 days without affecting contamination rates. O'Malley et al (1994) recommended not routinely changing pressure monitoring kits as this was associated with higher contamination due to increased violations, however, this recommendation is based on a single site, observational study. O'Grady et al (2002) reporting Centre for Disease Control and Prevention (CDC) guidelines recommend changing transducers for peripheral arterial catheters at 96 hour intervals. The NSW arterial catheter survey demonstrated variability in practice ranging from changing lines every 2 days to once a week. Based on consensus opinion of the Arterial GDN and O'Grady et al (2002), the recommendation of 96 hours was made.

The EVP did not agree with this recommendation (median 6, range 3-8). The main concern expressed was that the understanding that the CDC recommends a transducer change at 72hours(O'Grady 2002). There is an apparent error in the O'Grady document with 72 hours documented in a summary table of recommendations but 96 hours recommended within the text. Because of this probable misunderstanding and that four of eight panel members agreed with the recommendation there has been no change to the recommendation.

Number	Statement	Grade of recommendation
2b	Arterial pressure transducer system flush bags should be changed as necessary and at a maximum of 96 hours (in conjunction with catheter/transducer changes).	D

Assessment of body of evidence: D – Poor

The only identified reference in the literature that specifically related to flush bag changes (or hang time for flush solutions) was made by O'Grady et al (2002) who recommended replacement of the flush solution at the time the transducer is changed, their recommendation being 96 hours. As occasionally the flush bag may run out of fluid within that time (due to frequent blood sampling or dampened traces for example), the Arterial GDN recommendation has included changing the flush bag 'as necessary' to account for these circumstances. The NSW arterial catheter survey found the majority of ICUs changed their flush bags daily (22/28 ICUs), however consistent with the recommendations proposed by O'Malley et al (1994) unnecessary violations of any component of the arterial monitoring system (including flush bags) may increase the risk of bacterial contamination.

The EVP did not agree with this recommendation (median 6, range 1-8). The main concerns expressed were that the understanding that the CDC recommends (O'Grady 2002) a flush bag change at 72hours and the difference between current clinical practice and the recommendation. No economic data was included in the Guideline reviewed by the EVP. A 500ml bag of 0.9% saline costs \$1.38 (SWAHS stores department July 25 2007). The cost of changing the flush bag every day for four days is \$5.52 as opposed to \$1.38 if the flush bag is left insitu for 96 hours. Moreover there are significant costs differences when the costs of daily versus 96hour bag changes are extrapolated over different numbers of arterial catheters per annum (figure 1). Therefore due to the probable misunderstanding of the CDC recommendation together with the cost implications, this recommendation has not been changed.

Figure 1: Cost of flush bag changes

Figure 1: Cost of flush bag changes			
Arterial catheters per annum	Daily change	Change every 96hrs	Cost savings of 96hrs vs daily change
200	\$1,104	\$276	\$828
400	\$2,208	\$552	\$1,656
1000	\$5,520	\$1,380	\$4,140

Number	Statement	Grade of recommendation
2c	Arterial catheter dressings should be changed as necessary and at a maximum of 96 hours (in conjunction with catheter/transducer changes).	D

Assessment of body of evidence: D – Poor

The only identified reference in the literature that specifically related to dressing changes was made by O'Grady et al (2002) who recommended a weekly dressing change. The NSW arterial catheter survey demonstrated variability in practice with the largest proportion changing the dressing as necessary (14 out of 28 units). However, the Arterial GDN acknowledged that in order to change the arterial catheter transducer set, the arterial dressing needs to be removed to connect the new lines to the arterial catheter and therefore dressing changes need to occur at this time. Based on consensus opinion of the Arterial GDN and O'Grady et al (2002), the recommendation of 96 hours was made. As occasionally the dressing may lift or become soiled, the Arterial GDN recommendation has included changing the dressing 'as necessary' to account for these circumstances.

The EVP did not agree with this recommendation (median 6, range 3-8) however there were no reasons given. Therefore this recommendation was not altered.

Number	Statement	Grade of recommendation
2d	Arterial catheter insertion site should be assessed for signs of local infection and catheter integrity hourly and when arterial catheter dressings are changed.	Consensus opinion

Assessment of body of evidence: D – Poor

There was no literature identified during the search process that addressed research related to the type and frequency of arterial catheter nursing assessments, nor did the NSW arterial catheter survey specifically ask any questions related to this issue. Regular assessment of catheter and catheter site is recommended in critical care texts (Darovic 2004, Becker 2005). The Arterial GDN members stated that the arterial catheter insertion site should be assessed for local infection and catheter integrity (presence of swelling, erythema or discharge) at the arterial catheter insertion site hourly.

The EVP supported this recommendation (median 8, range 3-9) although some panel members were concerned over the frequency and subsequent clinical burden of an hourly assessment. This assessment process whilst frequent is not onerous in terms of time or process and is considered necessary to ensure that the patient experiences appropriate care. This results in a more accurate blood pressure reading and the timely identification of disconnections or infections.

Number	Statement	Grade of recommendation
3	Normal saline should be used as the continuous flush solution to maintain arterial catheter patency.	D

Assessment of body of evidence: D – Poor

Previous research, of variable methodological quality and age, has been undertaken to investigate the most appropriate flush solution for maintaining patency of arterial monitoring systems. Earlier research (American Association of Critical Care Nurses [ACCN] 1993; Clifton et al 1991; Zevola et al 1997) and a systematic review (Randolph et al 1998) concluded that heparinised solutions prolonged the patency of arterial catheters over time as compared to non-heparinised solutions, with Bolgiano et al (1990) concluding that a decreased dose of heparin (0.25 U/ml) was sufficient to maintain patency. However, Leighton (1990) in a small observational study did not find patency to be significantly decreased using a continuous normal saline flush solution. This finding was also the outcome of an RCT where 65 patients

were randomised to either a normal saline or heparin (500 units per 500ms) flush (Whitta, Hall, Bennetts, Welman and Rawlins 2006).

The administration of unfractionated heparin (UFH) is associated with the development of a rare but serious haematological disorder heparin-induced thrombocytopenia (HIT). The sequela of HIT includes deep vein thrombosis, pulmonary embolus, skin necrosis, limb ischemia, thrombotic stroke, severe haemorrhage, and myocardial infarction, with possible amputation or death. Although the level of exposure required is unclear limiting the use of UFH is recommended (Martel, N. 2005; Napolitano, Warkentin, AlMahameed and Nasraway 2006).

Recent clinical practice (as determined by the NSW ICU survey) indicates that the majority of ICUs used non-heparinised continuous flush solutions, being normal saline (22/28) and 5% dextrose (2/28). Given the lack of evidence supporting the use of a heparinised flush solution, possible sequelae of UFH therapy and current clinical practice it is the consensus opinion of the Arterial GDN members, that a non-heparinised normal saline flush solution be used to maintain patency of catheters. The EVP supported this recommendation (median 8, quartile 1-6, quartile 3-9).

Number	Statement	Grade of recommendation
4	The circulation of the limb distal to the arterial catheter insertion site should be assessed at least hourly.	Consensus opinion

Assessment of body of evidence: D – Poor

The presence of an arterial catheter in an artery has the potential to adversely affect the arterial blood supply to tissue distal to the catheter insertion. Furthermore, there exists a potential for the artery to become closed, whether temporarily or permanently, due to complications such as an embolus or thrombophlebitis. Established clinical practice would expect frequent assessment of circulation in a limb with an arterial catheter in situ, however, no literature was identified that addressed research related to the type and frequency of nursing assessments pertaining to the circulation in the limb distal to the arterial catheter (Darovic 2004). The NSW arterial catheter survey did not specifically address this issue. The consensus opinion of Arterial GDN members was that circulation of the distal limb should be assessed to ensure adequate perfusion (through evaluation of capillary refill, colour and warmth of the distal limb and presence of a pulse distal to the catheter insertion site) hourly. The EVP supported this recommendation (median 8, range 3-9).

Number	Statement	Grade of recommendation
5	Arterial Catheters and transducer lines must be secured to prevent dislodgment or disconnection.	Consensus Opinion

Assessment of body of evidence: D – Poor

The dislodgement of an arterial catheter and disconnection between the catheter and transducer lines are a significant safety issue for critically ill patient. Movement of the catheter itself within the artery may damage the artery as well as reduce the accuracy of the arterial blood pressure readings. Disconnection between the catheter and transducer lines poses a significant risk for life-threatening haemorrhage. Use of luer-locked connections to prevent disconnection between the catheter and transducer lines is a universal standard of care (Becker 2005), although there was no published research identified regarding this practice. Recommendations directed towards preventing the dislodgement or disconnection of an arterial catheter and transducer lines were formulated based upon the GDN members' clinical knowledge and the findings from the survey of practice. The survey indicated that there are a number of different methods used to achieve these goals. Prevention of dislodgment of the arterial catheter was achieved using four methods including: stitching the catheter in place (13/28, 46%); using a stitch plus sterile tape (5/28, 17.9%); using sterile or adhesive tapes alone (6/28, 21.4%); or using a commercially available product, Stat lock (4/28, 14.3%). Ensuring the transducer lines remained secure was achieved by: use of tape and splint (11/28, 39.3%); splint only (11/28, 39.3%); tapes only (4/28, 14.3%); or use of a Velcro band (2/28, 7.1%). However, the use of a splint to immobilise the wrist joint remains controversial, as there is the potential for neuromuscular injury with wrist hyperextension (Chowet et al. 2004). If splints are used it is recommended that the wrist is maintained in a neutral anatomical position (Darovic 2004, Becker 2005, Chowet et al. 2004) and not obscure the arterial catheter insertion site or connection between catheter and transducer line. Other practices, which will aid in detection of a potential complication related to arterial catheter and transducer line dislodgment and/or disconnection include:

- Ensuring the arterial monitoring alarms are set and switched on;
- Keeping limbs with arterial catheters on constant view and not under a sheet (although this may be difficult to achieve with a femoral arterial catheter);
- Frequent assessment of the insertion site to detect movement of the catheter and/or swelling;
- Checking the connections between the arterial catheter and transducer lines for tightness at the beginning of each shift.

The EVP supported this recommendation (median 9, range 7-9).

Number	Statement	Grade of recommendation
6	Closed pressure transducer sets should be used where possible to prevent patient infection and iatrogenic anaemia and clinician infection.	Consensus Opinion

Assessment of body of evidence: D – Poor

Three aspects of care must be considered when making a choice to use an open versus a closed pressure transducer set (PTS), these being: the risk of patient infection due to frequency of line violations, clinician infection due to exposure to blood products, and iatrogenic anaemia due to blood loss from frequent volume sampling. The NSW survey indicated that only 7 of 28 units (25%) use a closed PTS (3 of 8 Level 3 [JFICM], 3 of 8 Level 2 [JFICM] and 1 level 1 [JFICM] used both). The literature pertaining to closed versus open PTS is limited. Closed PTS have not been shown to limit iatrogenic anaemia except for patients who require frequent long-term blood sampling such as those patients receiving renal replacement therapy (Macisaac et al. 2003, Thorpe and Thomas 2000). No recent studies comparing open and closed PTS and the incidence of blood stream infection were found, however, the CDC guidelines (O'Grady et al. 2002) and American Association of Critical Care Nurses (AACN) (Becker 2005) recommend the use of closed PTS on the basis of prevention of blood stream related infection. Arterial catheters are used to obtain frequent arterial blood samples and there is a risk to the clinician of blood exposure. Closed PTS minimise this risk as specimens can be obtained without opening the PTS. Overall the arterial GDN members recommend that where possible closed PTS should be used. The EVP supported this recommendation (median 8, range 4-9).

Process of Guideline Development

The arterial guideline development network (Arterial GDN) developed the arterial catheter management guideline. The processes used were: identification of practice, literature review, audit of current practice and a consensus development conference.

The Arterial GDN was established at the 'Getting Evidence into Practice' workshop held on June 14 2005 (<http://intensivecare.hsnet.nsw.gov.au/five/htm/education.php>). The senior nurses were able to self-select which guideline to develop. In the period between June 2005 and December 2006 GDN meetings were convened via teleconference with ICCMU's CNC coordinating the process. At the initial meeting the scope and state of current practice was established and issues related to management of critically ill adults with an arterial catheter were brainstormed. At subsequent meetings a clinical question and literature review protocol were developed and literature review tasks allocated.

The focus of the Arterial GDN was to determine what clinical practices are the most effective in preventing infection and maintaining patency and security of arterial catheters in critically ill adults. The initial clinical review questions that were formulated by the Arterial GDN specific to the management of critically ill patients with arterial catheters were:

1. What is the best method for securing an arterial catheter to prevent dislodgement?
2. In the critically ill adult how frequently do arterial catheter transducers need to be changed to prevent catheter related infections?
3. What flush solution maintains arterial catheter patency in critically ill adults?

Further sub-group questions were developed at subsequent meetings and included:

1. The frequency of dressing changes to prevent infection?
2. Are tapes or sutures more effective for securing arterial catheters?
3. Does splinting improve arterial line security?
4. Do closed or open monitoring systems decrease the incidence of local or catheter related infections?
5. What observations, and how frequently should the arterial site and limb circulation be assessed?

Based on the development of these clinical practice questions, criteria were developed using the Patient, Intervention, Comparison and Outcome (PICO) model to guide the literature review process. The review sought to find studies that included the following criteria: the population of interest was adults in a critical care unit with an arterial catheter; study

interventions that addressed changing transducers, dressing procedures, continuous flush solutions, methods of securing lines to prevent dislodgement, frequency of line changes and methods of maintaining catheter patency; with outcome measures including absence of infection, catheter dislodgement, catheter patency and local or catheter related blood stream infections (CRBSI).

Using these PICO criteria, key words were identified to be included in the search strategy. These keywords were: arterial, pressure, transducer, flush solution, dressing, line security, insertion site, suturing and splinting. They were used in various combinations to search the Clinical Information Access Program (CIAP) databases such as CINAHL and Medline, Pubmed, Google and Google Scholar databases. Individual search strategies were developed by Arterial GDN members who focused on specific areas of arterial catheter management, such as dressings or frequency of line changes. The databases were searched for studies published between 1985 and 2005. The search was limited to studies published in English language only. It was acknowledged that this may limit identification of published research, however due to time and resource restrictions, translating non-English language papers were beyond the scope of this review. Other limitations of the search process were that sources of unpublished research were not accessed, use of search filters was limited and not all reference lists were checked for additional studies related to the GDN focus.

Studies identified from the individual search strategies that appeared to meet the inclusion criteria were retrieved and distributed by the ICCMU CNC to Arterial GDN members some weeks prior to the Intensive Care Collaborative Development Conference (ICC-CDC).

A critical appraisal tool was developed by the project manager and academic leader (see appendix A) and GDN members were subsequently trained in its application. Prior to ICC-CDC an on-line forum was established to promote discussion of evidence with respect to specific questions arising from the broader PICO question (<http://intensivecare.hsnet.nsw.gov.au/six/blogcms/forum/>).

As it became readily apparent that there was a paucity of published research pertaining to the management of critically ill adults with arterial catheters, the Arterial GDN developed an ICCMU Arterial Catheter survey, comprising semi-structured and open-ended questions aimed at eliciting information about the current clinical practices of catheters in Intensive Care Units (ICUs) in New South Wales. The survey was developed and assessed for content validity by several critical care clinicians experienced in the management of arterial

catheters. The survey was distributed via email to a GDN member (if available) otherwise the senior nursing person in all NSW ICUs, including those designated as high dependency. Twenty-eight out of 43 ICUs returned completed surveys, a response rate of 65%. The findings (refer to appendix 2), based on feedback of clinical experts, were used to inform the recommendation statements developed by the Arterial GDN.

Midway through 2006 a group of critical care academics from Australia and New Zealand were identified as academic facilitators for each GDN. A number of meetings were held to establish the final processes of guideline development in particular the taxonomy for levels of evidence and recommendations and consensus development (see Box A).

1. Description of Consensus development process

On Friday December 1 2006 the ICC-CDC was held where all of the GDNs met to develop the recommendations for practice under the facilitation of an Australasian critical care academic. Each GDN followed the processes outlined in Box A. Recommendations 1-4 were developed at the ICC-CDC whilst recommendations 5 and 6 were developed post meeting with consensus achieved on the first round via email.

Box A: Process of consensus development at ICC-CDC

1. Establish current practice
2. Revisit clinical question
3. Review papers
 - a. Include relevant papers
 - b. Assign level of evidence for each paper
4. Recommendation
 - a. Develop statement
 - b. Assign grade of recommendation from
 - i. The body of evidence
 - ii. Consensus opinion
 - iii. NSW ICU survey of arterial catheter and line practices
5. Assign agreement using Likert Scale
6. Review voting - consensus is a median of 7-9
7. Revisit process once only if consensus not reached

2. Guideline construction

The authors constructed this guideline using recommendations developed by those Arterial GDN members present at ICC-CDC and those formulated in January 2007. A summary of the events that occurred at the ICC-CDC were collated and distributed by the academic facilitator to absent GDN members to review and to subsequently comment and provide their consensus opinion on the wording of those recommendation statements developed at this time.

3. External Validation Process

Validation of the guideline was conducted in May 2007 by external validation panel (EVP) using a limited Delphi round was conducted.

Formation of Panels

Panel members (n=48) for all guidelines were identified using professional networks and associations and were allocated to a specific guideline using two processes. Firstly there were nine panel members who were approached directly because of their acknowledged expertise with a particular practice (including research or employment role). The other panel members were randomly allocated to a specific guideline by placing all names into a hat and assigning names sequentially to each guideline until names and panel positions were exhausted. In order to describe the panels, panel members were asked to provide limited demographic data. In addition they completed a 'conflict of interest' form. Table 3 lists panel members including affiliations.

Method of validation

Panel members received the draft guideline and the literature review (which included the data extraction tools completed by the GDN members) along with a recommendation agreement form. They were then asked to assign their level of agreement (likert 1-9) with the recommendation statement. A median score of 7 was set for consensus to be reached. Table 4 sets out the results of the EVP process for this guideline.

Table 3: Arterial Catheter - External Validation Panel Members

EVP role	Name	Position and Facility
Nursing academic	Dr Robyn Gallagher RN CT Cert BA (Psych) MN PhD	Associate Professor of Chronic and Complex Care, Course Coordinator - Masters (Honours) Programs, Faculty of Nursing, Midwifery and Health University of Technology, Sydney, NSW
Nursing academic	Dr Amanda Rischbeith RN, Grad Dip Intensive Care, MNSc PhD	Clinical Educator ICU Calvary Wakefield South Australia
Clinical nurse	Serena Knowles RN, BN (Hons), GradDipInfM, Grad Cert Clin Nurs, PhD candidate (3yr)	Clinical Nurse Specialist ICU St Vincents Public, NSW
Clinical nurse	Linda Brearley RN, IC Certificate, BEC	Nursing Director, Critical Care Division, Royal Perth Hospital, Western Australia
Clinical nurse	Linda Thomas BSc(Nursing), Post Grad Cert (Clinical Nursing – Critical Care)	Clinical Nurse/Research Coordinator, ICU Royal Perth Hospital, Western Australia
Clinical nurse	Therese Williams RN, PB ICU Cert, GradDip Clin Epi, MHthSc(by research)	Research Researcher, Critical Care Division Royal Perth Hospital, Western Australia
Medical specialist	Dr Graig McCalman MBChB (1993) FJFICM FANZCA	Director ICU Lismore Base Hospital, NSW
Medical specialist	Dr Doris Lam FANZCA FJFICM	Staff Specialist ICU St George Hospital, NSW

Table 4: EVP Consensus Results

Recommendation Number	Quartile 1	Median	Quartile 3	Outcome
1a	6.5	9	9	Validated
2a	4.5	6	7	not validated
2b	4	6	6.5	not validated
2c	5.25	6	6.75	not validated
2d	5.5	8	9	validated
3a	6	8	9	validated
4	7.5	8	8.5	validated
5	8	9	9	validated
6	5.5	8	9	validated

Integrative Literature Review

1. Introduction

A literature search strategy was developed by the GDN during teleconferences. The relevant clinical issues, related to nursing care of an arterial catheter inserted into a critically ill adult, were brainstormed. These could be categorised into four main categories: 1) transducers and lines; 2) dressings and skin preparation; 3) catheter security and suturing; and 4) flush solution and heparin. Each of these categories were assigned to a group of two GDN members who had the responsibility of identification and appraisal of the relevant literature. A structured research question was developed to reflect all categories at subsequent meetings. The generic critical appraisal tool was used to review each article. Efforts were made to ensure all articles were reviewed twice, however this had limited success.

2. Literature Search Protocol

The table below includes: the structured research question developed by the arterial GDN; the PICO and a combination of all search strategies used

Structured Research Question:			
What clinical practices are most effective in preventing infection and maintaining the patency and security of arterial catheters in critically ill adults?			
1. What is the best method for securing an arterial catheter to prevent dislodgement?			
2. In the Critically ill adult how frequently do arterial catheter transducers need to be changed to prevent catheter related infections?			
3. What flush solution maintains arterial catheter patency in critically ill adults			
P	Population (of interest)	Adults in a critical care unit with an arterial catheter	
I	Intervention	Changing transducers, dressings, flush solution, heparin (?), suture vs stat lock vs other, splint, antiseptis, arterial catheter, patency	
C	Control (group)		N/A ✓
O	Outcome (measured)	Absence of infection, dislodgement, thrombosis (?), patency, CRBSI	
Search Strategy			
Databases:		All at CIAP, plus Pubmed, Google, Scholar Google	
Key words:		Transducers, flush solution, dressings, catheter security, insertion site, suturing, splint	
Publication years:		2000-2005 , Flush fluids only 1985-2005	
Other search filters:			
English language only	Y		
Adult > 16	Y		
Human	Y		
Research	Y		

Abstract	Y		
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3. Literature Review Process

The generic critical appraisal tool was used to review each article (appendix 1). GDN members were trained to use the instrument. Efforts were made to ensure all articles were reviewed twice, however this had limited success.

4. Literature Synthesis Process

Article reviews were forwarded to the Project Officer and these compiled and then distributed to the GDN some months prior to the ICC-CDC. An online forum was established for GDN members to answer the relevant clinical questions, however this was not utilised by the group. At the ICC-CDC the group reviewed the articles to evaluate the level of evidence and relevancy to the clinical question. The summary tables on pages 27-35 outline the available evidence used to frame the guidelines recommendations. It should be noted that the levels of evidence taxonomy used in the Centre for Disease Control (O'Grady et al. 2002) (CDC) paper are different to the Australian National Health and Medical Research Council (NHMRC) and should not be used interchangeably.

5. Taxonomy for level of evidence and grade of recommendation

The Academic Committee discussed a number of alternate methods of assigning levels of evidence and grading recommendations and decided that the NHMRC (NHMRC 2005) taxonomy being most commonly referred to in Australian evidence based projects, was the most appropriate and user friendly for this project. Table 5 includes the standard NHMRC categories used to assign a hierarchical level of evidence related to interventional studies, together with the number of papers found by the Arterial GDN in each category. For completion one paper was a clinical guideline and did not fit discretely into a standard NHMRC level but has been listed here for completion. Table 6 includes the NHMRC criteria that was used to evaluate the overall body of evidence for a given clinical issue, and on which the guideline statements were based.

Table 5: NHRMC Designations of Levels of Evidence

Level	Intervention	Number of studies identified
I	A systematic review of level II studies	2
II	A randomised controlled trial	3
III-1	A pseudorandomised controlled trial (i.e. alternate allocation or some other method)	6
III-2	A comparative study with concurrent controls: <ul style="list-style-type: none"> • Non-randomised, experimental trial • Cohort study • Case-control study • Interrupted time series with a control group 	1
III-3	A comparative study without concurrent controls: <ul style="list-style-type: none"> • Historical control study • Two or more single arm study • Interrupted time series without a parallel control group 	0
IV	Case series with either post-test or pre-test/post-test outcomes	3
	Guideline paper	1

Table 6: NHMRC Grading of Recommendations

Component	A	B	C	D
	Excellent	Good	Satisfactory	Poor
Volume of evidence	several level I or II studies with low risk of bias	one or two level II studies with low risk of bias or a SR/multiple level III studies with low risk of bias	level III studies with low risk of bias, or level I or II studies with moderate risk of bias	level IV studies, or level I to III studies with high risk of bias
Consistency	all studies consistent	most studies consistent and inconsistency may be explained	some inconsistency reflecting genuine uncertainty around clinical question	evidence is inconsistent
Clinical impact	very large	substantial	moderate	slight or restricted
Generalisability	population/s studied in body of evidence are the same as the target population for the guideline	population/s studied in the body of evidence are similar to the target population for the guideline	population/s studied in body of evidence different to target population for guideline but it is clinically sensible to apply this evidence to target population*	population/s studied in body of evidence different to target population and hard to judge whether it is sensible to generalise to target population
Applicability	directly applicable to Australian healthcare context	applicable to Australian healthcare context with few caveats	probably applicable to Australian healthcare context with some caveats	not applicable to Australian healthcare context

6. Description of Literature identified

Although 22 papers were retrieved as a result of the search process, after closer review of the papers only 15 were found to be related to the Arterial GDN questions and therefore suitable for grading according to NHMRC guidelines. Table 5 presents the outcome of this process with most being Level III or IV evidence. Although two systematic reviews were identified related to arterial issues, the application of their findings were limited due to a number of methodological issues (Randolph et al. 1998, Fowler and Berenson 2003). As mentioned, the CDC guidelines (O'Grady et al. 2002) which addressed several of the Arterial GDN questions were identified but could not be graded against the NHMRC interventional criteria and consequently were just listed.

Table 7 includes the summary tables for the literature used to inform the development of recommendations. Table 8 contains those papers, which were reviewed but not used to develop recommendations for practice. The data extraction tools for all papers reviewed can be found at the ICCMU website under the following URL. [This will be developed when the guideline is published on the internet]. In general most papers were found to be dated and of a poor quality and although several RCT were identified, significant issues related to methodology, sample size and reporting were found.

Table 7: Summary Tables of Research Papers included

Short reference	Design/Method	Sample Description	Outcomes/findings	Methodological Quality			
AACN (1993) Thunder project(AACN 1993)	Multi site two group randomised clinical trial Not blinded for logistical reasons Site coordinators Randomisation by number blocks of 30	<i>Inclusion:</i> Arterial line 18 yrs <i>Exclusion:</i> Platelets < 100 000 Already in a drug trial Physician order Previously in study known allergy to heparin Pregnancy <i>Sample Description</i> 198/239 site enrolled submitted data for 5037 patients 51.1% heparin/48.9% non heparin No comparative data on groups.	Probability of patency	<ul style="list-style-type: none"> Not blinded Non standard heparin concentration Limited patient information to see if randomisation was achieved. Data on confounding variables not collected or attended to including <ol style="list-style-type: none"> Number of times pressure bag < 300 mmHg A consistent method of line stabilisation 			
Time			Heparin		Non-heparin		
24			0.97		0.93		
48			0.94		0.86		
Level of Evidence: II NHMRC			72	0.90	0.79		
Aly, R., et al (1988) Restriction of bacterial growth under commercial catheter dressings.(Aly et al. 1988)	Experimental design The growth of bacteria under different conditions was compared: Experimental dressings A - three alternate transparent dressings B – gauze and tape Control: A – saran wrap B – uncovered skin All skin prepared using povidone-iodine and 70%	2 groups – 50 normal healthy individuals - 49 hospital inpatients – 25 on oral antibiotics. - 57% were women - 72% were white - Mean age 44.6 years	<ul style="list-style-type: none"> No difference found between the transparent film dressings & gauze dressing in growth of normal flora. Higher bacterial populations developed on saran wrap + control site exposed for 72 hrs in patients compared to healthy volunteers. 	<ul style="list-style-type: none"> Limited literature R/V Applications to critically ill patient is limited 			
Level of Evidence: III-1 NHMRC							
Bolgiano et al (1990) The effect of two concentrations of heparin on arterial line patency (Bolgiano et al. 1987)	RCT - Double blind Pharmacy prepared infusions using randomisation table Surgical ICU (70%) Medical ICU (30%) May 1986 – 1987	N=104	All	25u/ml	1u/ml	<ul style="list-style-type: none"> No differences between groups in terms of coagulation studies and platelet counts Only 41/104 remained in place > 3days 	<ul style="list-style-type: none"> Unknown homogeneity of patients No comparison of blood values between arterial line & phlebotomy blood Limited description of outcome measures Reliability? Limited sample size
Level of Evidence: II NHMRC			Male	67	35		
		Female	37	19	18		
		Age	22-101	50.4 (22-83)	59.5 (22-101)		
		Wide variety of diagnoses					

Short reference	Design/Method	Sample Description			Outcomes/findings			Methodological Quality
Chowet et al (2004) Wrist hyperextension leads to median nerve conduction block: implications for intra-arterial catheter placement. Anaesthesiology; 100: 287-91(Chowet et al. 2004)	Prospective descriptive comparative Opposite wrist used as control	12 volunteers X 36			- X wrist angle 72 ± 6 10/12 CSAP \downarrow 20% baseline over 60 mins All CSAP amplitude \downarrow $17 \pm 10\%$ baseline with severe parasthesia CMAP less dramatic Return to normal quickly			<ul style="list-style-type: none"> • Technician not blinded • Healthy patients
Level of Evidence: III-1 NHMRC								
Clifton, G. D., P. Branson, et al. (1991). "Comparison of normal saline and heparin solutions for maintenance of arterial catheter patency." <i>Heart & Lung</i> 20: 115-118(Clifton et al. 1991)	Randomised control trial Study period 4 days Consecutive enrolment Randomisation method not described Setting: United states general medical ICU Study drug: Heparin 4u/ml Inclusion Arterial Catheter for therapeutic or diagnostic Radial artery Adequate collateral circulation Exclusion Coagulation disorder Platelets < 50 000 Systemic anticoagulants	N= 30	Normal Saline n= 15	Heparin n=15		Normal Saline n= 15	Heparin n=15	<ul style="list-style-type: none"> • Limited description confounding variables including Diagnosis, Level of Consciousness and how the catheters were secured • Significant Bias due to the small sample size and lack of description regarding randomisation • #% of shifts where problem occurred or corrective action was required
		Male	7	8	Total Catheter Failure	5	1	
		Age	56.2 ± 15.1	48 ± 17	Patent at 40 hrs	50%	100%	
		Attempts	2.6 ± 1.4	2.3 ± 1.6	Patent at 96hrs	52%	96%	
		Baseline platelet count & TT similar			Damp wave# \blacklozenge	26	13	
Subcutaneous heparin	4	4	Catheter \blacklozenge Occlusion#	12	4			
			Manipulation of catheter#	34	17			
			\blacklozenge P<0.01					

Short reference	Design/Method	Sample Description	Outcomes/findings	Methodological Quality
Gabel – Hughes, et al (1990) Methods of arterial skin preparation and dressing. (Gabel-Hughes and Geelhoed 1990)	Prospective randomised control trial Interventions: <u>Control:</u> iodophor pre-insertion, alcohol wipe post-insertion, iodophor ointment post-insertion with Gauze dressing <u>Study:</u> 'IV Prep' [Smith and Nephew (triclosan active ingredient)] before & after with moisture permeable transparent dressing [uniflex, Smith & Nephew] Dressings and lines changed daily <u>Evaluation:</u> Daily assessment for complications <u>Outcomes:</u> Infection (redness, inflammation, pain, tenderness, exudate etc) Other line complications Demographics	60 surgical patients 30 in each group Very similar age Similar spread through neurosurgery/cardiothoracic & other.	No complication in either group Control group: lines patent 1.8 days vs study group of 1.6 days with no differences between groups Both methods found to be safe. Study group lines required fewer products & steps & provided constant visual access to arterial site.	<ul style="list-style-type: none"> Limited information supplied including no inclusion/exclusion criteria randomisation method criteria for infection or patent line results only briefly described
Level of Evidence: III-1 NHMRC				
Leighton, H. (1994) Maintaining the patency of transduced arterial and venous lines using 0.9% sodium chloride. Intensive and Critical Care Nursing 10: 23-25. (Leighton 1994)	3 month feasibility study of five different transducer delivery system All patients transduced with 500 mls normal saline at 300 mmHg pressure to deliver 3ml/hr	No description of patients	CVC – no problems Arterial Line – 33% due to clotting, inaccuracy or malfunction	<ul style="list-style-type: none"> There is very limited information reported Small Sample size No comparative group Limited Description of how data collection was organised Overall design poor
Level of Evidence: IV NHMRC				

Short reference	Design/Method	Sample Description	Outcomes/findings			Methodological Quality
Lorente, L., et al. (2004) Catheter-related infection in critically ill patients. Intensive Care Medicine 30: 1681-1684 (Lorente et al. 2004)	Prospective descriptive study over 18 months Arterial Catheter changed at 7 days. Daily betadine & gauze dressing Transducer changed 96 hrs All tips cultured	988 patients male 50% (60.17) Age 55.6 (± 18.4 yrs) Apache II 13.65 (± 5.83) LOS 8.6 (± 12.3) Death 142 (14.3%) Heart S _x 49.6%, cardiology 8.6% Neurological 12.1%, trauma 11.8%, intoxication 2.9%, respiratory 7.2%, digestive 6.5%	No differences between AC insertion sites & incidence of CRLI & CRBSI CVC CLRI > AC (4.7% vs 0.9% re 1000 patients days, p < 0.001) CRLI 0.5 % (7/1231) CRBSI 0.2% (3/1231)			<ul style="list-style-type: none"> Hawthorne effect of observing improving practice, although it did go over a long period of time.
Level of Evidence: IV NHMRC						
Luskin let al (1986) Extended use of disposable pressure transducers. A bacteriologic evaluation. JAMA 255(7):916-920(Luskin et al. 1986)	Randomised control trial Eligible patients were randomised to have their transducers changed every 2 days or every 8 days. The patents were removed from the study following 8 days. At the completion of the study period where feasible, the catheter tips where sent for culture. Cultures of transducer fluid were taken on entering the study and then daily. If the patient had a Swan Ganz it was assigned to the same group as the arterial line	112 patients where included in the study with 157 courses of arterial pressure monitoring. 62 in the 2 day group and 58 in the extended period group (39- 8 daily and 19- 4 th daily changes)	91% of arterial transducers were contamination free at 4 days 16 contaminated transducers were identified. No difference in the incidence between timed groups			<ul style="list-style-type: none"> Questionable as the protocol was changed mid way through the study as the numbers of contamination were greater in the 8 day group though it did not reach significance
Level of Evidence: III-1 NHMRC						
O'Malley, M.K., Rhame, F.S., Cerra, F.B. McComb, R.C. Value of routine pressure monitoring system changes after 72 hours of continuous use. Critical Care Medicine 22; 1424 – 1430. (O'Malley et al. 1994)	Prospective observational study of microbiological contamination of all pressure monitoring systems for 10 calendar months if the line was expected to be insitu ≥ 96 hrs. <u>Interventions:</u> Routine accessing of lines by haemodynamic monitoring team. At 72 hrs 1 ml of fluid from proximal stopcock of monitoring lines was cultured using a clean technique <u>Outcomes:</u> Positive cultures definition applied.	Any patient with invasive monitoring catheter expected to remain > 96 hrs 120 enrolled with 19 eliminated 101 patients with 234 catheters and 333 monitoring kits. 451 intervals of closed system ≥ 96 hrs.		No	All systems & cultures	<ul style="list-style-type: none"> Bias in sample Difficult to correlate the number of patients with the facility size and timeline; Not all patients in the facility were enrolled in study Unable to differentiate between results for the different intravascular monitoring lines Limited patient information.
Level of Evidence: IV NHMRC			No. of intervals	451	-	
	No. of cultures	1991	4			
	Kits	383	4			
	Catheters	265	3			
	Patients	120	2			

Short reference	Design/Method	Sample Description	Outcomes/findings	Methodological Quality																																									
Randolph AG et al (1998) Benefit of heparin in peripheral veous and arterial catheters: systematic review and meta-analysis of randomised controlled trials. BMJ 316: 969-975(Randolph et al. 1998)	Systematic review <i>Clinical Question</i> – To evaluate the effect of heparin on duration of catheter patency and on prevention of complications associated with use of peripheral venous and arterial catheters. <i>Population</i> – Adult and Paediatric	<i>Timeline:</i> 1966-April 1997 <i>Data bases:</i> Embase – 1974-1996 Medline 1996-april 1997 Handsearches: Product (heparin bonded catheters) inserts for references National Intravenous therapy Association Journal 1985-1992 <i>Keywords:</i> Catheters, catheter indwelling heparin, randomisation, random allocation, RCT randomised response technique controlled clinical trials (randomised).	Single multicentre study – heparin effective prolongs life of peripherally placed arterial pressure monitoring devices but concentration is unknown (0.25 U/ml vs 1 unit/ml satisfactory.)(AACN 1993) Relative risk of heparin benefit Clifton et al 1991 0.43 (95%CI 0.14 - 1.35) 3/15 with heparin vs 7/15 without heparin ACCN 1993 0.51 (95%CI 0.42 – 0.61) 160/2573 with heparin vs 301/2464 without heparin Common RR 0.51 (95%CI 0.42 – 0.61)	<ul style="list-style-type: none"> Does not include all relevant concepts or variables such as: <ol style="list-style-type: none"> 1. Pressure in pressure bag; 2. Use of fast flush; 3. Stabilisation of catheter Heparin concentration is variable in studies included Although test for heterogeneity was satisfactory the weight of the ACCN THUNDER project to the RR assessment brings the result into question. See the previous assessment of the THUNDER paper 																																									
Level of Evidence: I NHMRC	Data abstraction by two investigators																																												
Thorpe, S. and Thomas, A.N. (2000). The use of a blood conservation pressure transducer system in critically ill patients. Anaesthesia 5: 27-31.	RCT (Randomisation by sealed envelope,) <u>Intervention:</u> Use of either a VAMP closed pressure transducer set (PTS) or a conventional PTS On removal of the catheter a 3cm distal section was sent for culture (Maki technique) Standard care: 500u heparin/500 mls N/S. Tegaderm and povidone dressing twice weekly <u>Outcome:</u> Catheter colonisation – growth of > 15CFUs with no organism in peripheral sample Standard definitions used	<table border="1"> <thead> <tr> <th></th> <th>VAMP</th> <th>Control</th> <th></th> <th>VAMP</th> <th>Conventional</th> </tr> </thead> <tbody> <tr> <td>n</td> <td>48</td> <td>52</td> <td>Arterial Line Colonisation</td> <td>20/58</td> <td>22/62</td> </tr> <tr> <td>Age</td> <td>40 (18)</td> <td>43 (15)</td> <td>PA Line</td> <td>9/38</td> <td>15/37</td> </tr> <tr> <td>Male</td> <td>33</td> <td>34</td> <td>Positive blood culture</td> <td>5/48</td> <td>8/52</td> </tr> <tr> <td>Apache II</td> <td>18 (18)</td> <td>19 (7)</td> <td>No organism grown from catheter</td> <td></td> <td></td> </tr> <tr> <td>Daily TSS</td> <td>2 38 (10) 5 35 (10)</td> <td>37 (9) 33 (8)</td> <td>HB Equal ↑ Transfusions in Control group in patients who required RRT.</td> <td></td> <td></td> </tr> <tr> <td>Survivors to discharge</td> <td>28</td> <td>36</td> <td></td> <td></td> <td></td> </tr> </tbody> </table>		VAMP	Control		VAMP	Conventional	n	48	52	Arterial Line Colonisation	20/58	22/62	Age	40 (18)	43 (15)	PA Line	9/38	15/37	Male	33	34	Positive blood culture	5/48	8/52	Apache II	18 (18)	19 (7)	No organism grown from catheter			Daily TSS	2 38 (10) 5 35 (10)	37 (9) 33 (8)	HB Equal ↑ Transfusions in Control group in patients who required RRT.			Survivors to discharge	28	36				<ul style="list-style-type: none"> Line site and colonisation data not reported. Confounding variables → immune status (↑ infection risk) → diagnostic groups → antibiotics High transfusion Hb (different to Aust) Pre preparation of PTS No information re access of sampling port on VAMP No consort supplied Potential bias
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Short reference	Design/Method	Sample Description			Outcomes/findings				Methodological Quality
Whitta, Hall, Bennetts, Welman and Rawlins (2006) Comparison of normal or heparinized saline flushing on function of arterial lines, Critical Care and Resuscitation, 8 (3): 205-7 Level of evidence: III-1	Blinded RCT Level 2 ICU New Zealand 20g arterial catheters in radial, brachial or femoral arteries. <u>Intervention:</u> 500mls 0.9% saline flush OR 500 units in 500mls 0.9% saline. Outcome measure: subjective scale with the function of the line scored by nurse at end of shift. <u>Scale:</u> 3- functioning well for monitoring and sample taking 2 – functioning well most of the time, requires some attention 1 – functioning poorly 0 – required changing	Patient	Saline n=35	Heparinized saline n=30	Function of arterial lines: Heparin group: 83% mean Saline group: 82% mean				<ul style="list-style-type: none"> Possible type II error due to small sample size Limited reporting of results including Distribution of intervention amongst different access vessels Only Mean score of each group Outcome measures are open to bias No report concerning development Unknown interrater reliability Scale is subjective Confounding variables (eg how lines were managed with respect to stabilisation and pressure bag pressure) Randomisation method not reported No consort diagram
		Male	18	14					
		Female	17	16					
		Mean age	58	50					
		LOS	5.8	6.6					
Zevola, et al (1997) Comparison of heparinized and nonheparinized solutions for maintaining patency of arterial and pulmonary artery catheters. American Journal of Critical Care 6 (1) 52-55. (Zevola et al. 1997) Level of Evidence: III-2 NHMRC	Large tertiary medical centres in US ICU. Block allocation Phase I Heparinized sol ^{ns} Phase II Non heparinized sol ⁿ Consecutive patient enrolment before/after design <u>Inclusion:</u> >18 PAC or AC as part of routine <u>Intervention:</u> Heparin 1u/ml in 500 mls N/S or normal saline. <u>Outcomes:</u> 12 hourly assessment of: - blood could be withdrawn with 3 ml catheter - good waveform (dampening) - irrigated with in line flush Failure if any of these occurred.	N=226	Heparin n 121	Non Heparin 105	Failure rate	Heparin	Non Heparin	Chi score	<ul style="list-style-type: none"> Study design is open to considerable bias including factors such as: Not blinded or randomised Confounding variables not included: patient diagnosis; no of times catheter accessed; or how lines were stabilised Enrolment of participants Multiple data collectors – inter-rater reliability not assessed Time to failure not reported or no. of reinsertions.
PAC		114	98	Anti coagulant used	9/101	18/69	7.81 p<0.01		
AC		113	90	Anti coagulant Not used	0/12	9/21	5.08 p<.025		
Age P> 0.05		60.8	61.7	Results are for arterial catheters only					
Sex reported as equal			Groups were similar for treatment with coagulants (vitamin K and protamine however patients who received a heparinised solution were more likely to receive anti-coagulants [CHI (1)=4.91, p,0.025]						

O'Grady (2002) Guidelines for the prevention of intravascular catheter-related infections. Infection control and hospital epidemiology 23 (12) (O'Grady et al. 2002)			
Focus of Guideline	Organisation	Process of guideline creation	Review method
<ul style="list-style-type: none"> Prevention of catheter related blood stream infection (CRBSI) (relate to AG) Education CHx2% for skin prep 	Healthcare Infection Control Practice Advisory Committee US based broad-based consultative committee	Limited information available	Recommendations use CDC/HICPAC systems Category 1A: strongly recommended for implementation and strongly supported by well-designed experimental clinical or epidemiologic studies. Category 1B: strongly recommended for implementation and supported by some experimental, clinical or epidemiologic studies and a strong theoretical rationale. Category 1C: Required by state or federal regulations, rules or standards Category II: suggested for implementation and suggestive clinical or epidemiologic studies or a theoretical rationale. No recommendations: Unresolved issue: issue where evidence is insufficient or not consensus regarding efficacy exists
Healthcare worker education & training 1. Educate regarding indicators for use, LOE-1A 2. Assess knowledge of adherence to guidelines LOE : 1A. 3. Ensure appropriate nursing mix : LOE - 1A.	Surveillance 1. Monitor & assess daily for infection: LOE-1B. 2. Record operator date & time of catheter insertion & dressing on a standardised form : LOE-II. 3. Do not routinely culture catheter tips LOE-1A.	Hand hygiene 1. Observe proper hand hygiene procedures LOE- 1A 2. Gloves do not obviate the need for hand hygiene LOE-1A 3. Clean or sterile gloves when changing dressings. LOE -IC	
I. Selection of pressure monitoring system	Recommendation Use disposable, rather than reusable transducer assemblies when possible Level of Evidence Category IB	<ul style="list-style-type: none"> Donowitz LG, Marsik FJ, Hoyt JW, Wenzel RP. <i>Serratia marcescens</i> bacteremia from contaminated pressure transducers. JAMA 1979; 242: 1749-1751. Tenold R, Priano L, Kim K, Rourke B, Marrone T. Infection potential of nondisposable pressure transducers prepared prior to use. Crit Care Med 1987; 15: 582-583. 	
II. Replacement of catheter and pressure monitoring system	Recommendation 1 A. Do not routinely replace peripheral arterial catheters to prevent catheter-related infections. Level of Evidence Category II	<ul style="list-style-type: none"> Thomas F, Burke JP, Parker J, et al. The risk of infection related to radial vs femoral sites for arterial catheterisation. Crit Care Med 1983; 11: 807-812. Eyer S, Brummitt C, Crossley K, Siegel R, Cerra F. Catheter-related sepsis: prospective, randomized study of three methods of long-term catheter maintenance. Crit Care med 1990; 18: 1073-1079. Raad I, Umphrey J, Khan A, Truett LJ, Bodey GP. The duration of placement as a predictor of peripheral and pulmonary arterial catheter infections. J Hosp Infect 1993; 23: 17-26. Leroy O, Billiau V, Beuscart C, et al. Nosocomial infections associated with long-term radial artery cannulation. Intensive Care Medicine 1989; 15: 241-246. 	
	Recommendation 2 B: Replace disposable or reusable transducers at 96-hour intervals. Replace other components of the system (including the tubing, continuous-flush device, and flush solution) at the time the transducer is replaced. Level of Evidence Category IB	<ul style="list-style-type: none"> Mermel LA, McCormick RD, Springman SR, Maki DG. The pathogenesis and epidemiology of catheter-related infection with pulmonary artery Swan-Ganz catheters: a prospective study utilizing molecular sub-typing. Am J Med 1991; 91: 197S-205S. Luskin RL, Weinstein RA, Nathan C, Chamberlin WH, Kabins SA. Extended use of disposable pressure transducers: a bacteriologic evaluation. JAMA 1986; 255: 916-920. 	

O'Grady (2002) Guidelines for the prevention of intravascular catheter-related infections. Infection control and hospital epidemiology 23 (12) (O'Grady et al. 2002)		
III. Care of pressure monitoring systems A. General measures	Recommendation 1 Keep all components of the pressure monitoring system (including calibration devices and flush solution) sterile. Level of Evidence Category IA	<ul style="list-style-type: none"> • Donowitz LG, Marsik FJ, Hoyt JW, Wenzel RP. <i>Serratia marcescens</i> bacteremia from contaminated pressure transducers. JAMA 1979; 242: 1749-1751 • Fisher MC, Long SS, Roberts EM, Dunn JM, Balsara RK. <i>Pseudomonas maltophilia</i> bacteremia in children undergoing open-heart surgery. JAMA 1981; 246: 1571-1574. • Weinstein RA, Emori TG, Anderson RL, Stamm WE. Pressure transducers as a source of bacteremia after open-heart surgery: report of an outbreak and guidelines for prevention. Chest 1976; 69: 338-344.
	Recommendation 2 Minimise the number of manipulations of and entries into the pressure monitoring system. Use a closed-flush system (ie, continuous flush), rather than an open system (ie, one that requires a syringe and stopcock), to maintain the patency of the pressure monitoring catheters. Level of Evidence Category II	<ul style="list-style-type: none"> • Mermel LA, Maki DG. Epidemic bloodstream infections from hemodynamic pressure monitoring: signs of the times. Infect control Hosp Epidemiol 1989; 10: 47-53. • Shinozaki T, Deane RS, Mazuzan JE Jr, Hamel AJ, Hazelton D. Bacterial contamination of arterial lines: a prospective study. JAMA 1983; 249: 223-225.
	Recommendations 3 When the pressure monitoring system is accessed through a diaphragm rather than a stopcock, wipe the diaphragm with an appropriate antiseptic before accessing the system. Level of Evidence Category IA	<ul style="list-style-type: none"> • Mermel LA, Maki DG. Epidemic bloodstream infections from hemodynamic pressure monitoring: signs of the times. Infect control Hosp Epidemiol 1989; 10: 47-53.
	Recommendation 4 Do not administer dextrose-containing solutions or parenteral nutrition fluids through the pressure monitoring circuit. Level of Evidence Category IA	<ul style="list-style-type: none"> • Mermel LA, Maki DG. Epidemic bloodstream infections from hemodynamic pressure monitoring: signs of the times. Infect control Hosp Epidemiol 1989; 10: 47-53. • Solomon SL, Alexander H, Eley JW, et al. Nosocomial fungemia in neonates associated with intravascular pressure-monitoring devices. Pediatr Infect Dis 1986; 5: 680-655.* • Weems, JJ Jr, Chamberland ME, Ward J, Willy M, Padhye AA, Solomon SL. <i>Candida parapsilosis</i> fungemia associated with parenteral nutrition and contaminated blood pressure transducers. J Clin Microbiol 1987; 25: 1029-1032.

O'Grady (2002) Guidelines for the prevention of intravascular catheter-related infections. Infection control and hospital epidemiology 23 (12) (O'Grady et al. 2002)		
B. Sterilization or disinfection of pressure monitoring systems.	<p>Recommendation 1 Use disposable transducers</p> <p>Level of Evidence Category IB</p>	<ul style="list-style-type: none"> • Mermel LA, Maki DG. Epidemic bloodstream infections from hemodynamic pressure monitoring: signs of the times. Infect control Hosp Epidemiol 1989; 10: 47-53. • Solomon SL, Alexander H, Eley JW, et al. Nosocomial fungemia in neonates associated with intravascular pressure-monitoring devices. Pediatr Infect Dis 1986; 5: 680-655. • Villarino ME, Jarvis WR, O'Hara C, Bresnahan J, Clark N. Epidemic of <i>Serratia marcescens</i> bacteremia in a cardiac intensive care unit. In J Clin Microbiol 1989; 27:2433-2436
	<p>Recommendation 2 Sterilize reusable transducers according to the manufacturers' instructions in the use of disposable transducers is not feasible.</p> <p>Level of Evidence Category IA</p>	<ul style="list-style-type: none"> • Mermel LA, Maki DG. Epidemic bloodstream infections from hemodynamic pressure monitoring: signs of the times. Infect control Hosp Epidemiol 1989; 10: 47-53. • Solomon SL, Alexander H, Eley JW, et al. Nosocomial fungemia in neonates associated with intravascular pressure-monitoring devices. Pediatr Infect Dis 1986; 5: 680-655. * • Villarino ME, Jarvis WR, O'Hara C, Bresnahan J, Clark N. Epidemic of <i>Serratia marcescens</i> bacteremia in a cardiac intensive care unit In J Clin Microbiol 1989; 27:2433-2436. <p>*Editorial error in report</p>

Table 8: Summary Table of Research Papers not included

Full name of paper	Reasons for non inclusion
Boxleitner TJ & Valle M. (2001) Measuring "hang time": Contamination of intra-arterial flush solutions over time. Dimensions of Critical Care Nursing; Nov/Dec (20) 6: 38-41	Poor study design with significant bias and poor reporting
Covey et al (1988) Infection related to intravascular pressure monitoring: effects of flush and tubing changes American Journal of Infection Control , 16(5)206-213	Very small sample size Control of confounding variables Pilot study
Fowler, M. (2003) Blood Conservation in the Intensive care Unit. Crit Care Medicine 2003 31(12):	Quality of literature review is poor
Kaye et al (2001) Patency of radial arterial catheters. American Journal of Critical Care, 10(2):104-111	Did not address the PICO question
Mimoz et al (1996) Prospective randomized trial of two antiseptic solutions for prevention of central venous or arterial catheter colonization & infection in intensive care patients. Critical Care Medicine, 24(11) 1818-1823	Results superseded by O'Grady Distribution of patients in study arms did not account for confounding variables such as patient risk.
De Neef, M., Heijboer, H., van Woensel, J.B.M., and de Hann, R.J. (2002) The efficacy of heparinisation in prolonging patency of arterial and central venous catheters in children: a randomized double blind trial. Paediatric Hematology and Oncology, 19: 553-560.	Paediatric population with median age of 28 months Size of arterial catheter is 20g
Ousmane Traore (2005) Prospective study of arterial and central venous catheter colonization and of arterial- and central venous catheter- related blood stream bacteremia in intensive care units. Critical Care Medicine, 33 (6): 1276-1280	Epidemiology study
Peruzzi et al (1996) Microbial contamination of blood conservation devices during routine use in the critical care setting: results of a prospective randomized trial. 24(7): 1157-1162	Poor quality RCT, low sample size. Comparison between two closed pressure transducer systems
Woda et al (1999) On the dynamic performance of the Abbott safe set blood-conserving arterial line system. Journal of Clinical Monitoring and Computing. 15: 215-221	Did not address PICO question

Appendix 1 – Data Extraction Tools

Primary Study	The empty cells are for describing or discussing the concept above. If RCT use validity Checklist at bottom of page - Cells will expand / use small font			Use article in systematic review narrative Yes /No		
Full reference Ethics approval sort/gained Yes/No						
Study Aims/Objectives	Setting	Sample Inclusion/exclusion criteria	Interventions	Outcome Measure/s		
Short reference	Design/Method	Sample Description	Outcomes/findings	Methodological Quality		
Is the literature review adequate? Yes/No	Does the method suit the question/s? Yes/No	Sample size calculated and then achieved? Yes/No	Statistical significance? Yes/No	What are the authors conclusions ?		
Are data collection instruments adequately described? Yes/No	RCT or quasi-experimental? Yes/No (RCT score)	Is the sample homogenous? Yes/No	Clinical significance? Yes/No	Clinical Bottom Line		
Were data collection instruments validated? Yes/No	Were the statistics used appropriate? Yes/No	Were all patients enrolled accounted for? Yes/No	Is there enough information to judge results? Yes/No			
Randomised Control Trial Validity Checklist #		Yes	No	?		
Was the assignment to treatment groups really random?					Were the control and treatment groups comparable at entry?	
Were the participants blinded to treatment allocation?					Were groups treated identically other than for the named interventions?	
Was allocation to treatment groups concealed from allocator?					Were the outcomes of people who withdrew described and include in the analysis (ie was the analysis by intention to treat?)	
Were those assessing outcomes blind to the treatment allocation?					Were outcomes measured in a reliable way?	
					Was an appropriate statistically analysis used?	

Reviews – systematic and narrative → Use one per article which is a review of the literature. → Please be brief. Cell size is locked so add text; use a smaller font size to fit your conclusions in. → Where yes/no is asked for, text can be added to flesh out answer. → Where a number exists, please refer to the expanded question. → For the databases searched please add a tick <input checked="" type="checkbox"/> and describe the hand search strategy.				1. Is there an explicit review plan documented? 2. Was an explicit search strategy documented? 3. Was an explicit article review method used? 4. Were points 1-3 covered adequately? 5. Does the summary of each reviewed study reflect the essential components of the study design, research process and analysis techniques? 6. Is the organisation of the reviewed studies chronological and logical? 7. Does the organisation of the reviewed studies lead the reader to the same conclusions as the authors?			
Full Reference ⇨							
1 - Review Plan - yes/no		3 - Review Method - yes/no		Findings		Synthesis	
Clinical Question -		What was the article review method?		Are all the relevant concepts and variables included? yes/no		6 - Organisation chronological/logical? yes/no	
→ Population -				5 - Summary yes/no		7 - Organisation ⇨ Conclusions? yes/no	
→ Intervention/s		Are all articles found accounted for? yes/no		What are the key findings of the Review?			
→ Outcome/s		Type of review?					
2 - Search Strategy		4 Quality of the review –					
Keyword/s (list)		Limits (list)					
Search Time Line				Are the conclusions of the authors warranted? Yes/no & discuss			
Data Bases – adequate? Y/N				Please tick list below <input checked="" type="checkbox"/>			
CINAHL		Pubmed		Embase		Cochrane	
Psych info		DARE		Hand search		Other	

Appendix 2 - Survey ~ Arterial Catheter & Line Practice

Aim

To identify the nursing management practices of arterial catheters in NSW intensive care units (ICU)

Method

1. 14 item survey was developed and content validity was assessed by several senior critical care clinicians
2. The survey was distributed via email to all NSW ICUs including those designated as high dependency. The survey was sent to a guideline development network (GDN) member (if available) or if not to the most senior nursing staff.
3. Follow-up emails were made at week 1 and 2.
4. Completed surveys could be returned via email or fax and were directed to an ICCMU administrative assistant.
5. Data was entered onto an excel spreadsheet and analysed in SPSS 11 (student version)

Results

1. 29 surveys were returned with 2 from 2 hospitals. One duplicate was discarded however the other was kept because this came from a hospital with two distinct ICUs. This left 28 surveys for consideration. See table 1
2. 28/43 65% return rate
3. The results are summarised in table 2.
4. Each question was cross tabulated against JFICM level of ICU and whether the unit has a policy. These results follow table 2

	JFICM level				Total
	1	2	3	HDU	
Greater Southern AHS	1	2		1	4
Greater Western AHS	2	1			3
Hunter-New England AHS		1	1		2
North Coast AHS		2			2
North Sydney/Central		2	1		3
South Eastern Sydney#		2	5		7
South Western Sydney	1	1	2		4
Sydney West AHS		1	2		3
Total	4	12	11	1	28

2 surveys from 1 hospital however represents 2 units

Table 2

TRANSDUCER LINES																													
<p>1- How often is the arterial catheter transducer line changed?</p> <ul style="list-style-type: none"> • 13/28 changed at 3 days • However the distribution was quite variable and 6 hospitals that nominated 'other' failed to qualify this. • JFICM 3 units were more varied in their Responses (range 2-7days) 	<p>Statistics</p> <p>QU1EXTRA</p> <table border="1"> <tr> <td>N</td> <td>Valid</td> <td>22</td> </tr> <tr> <td></td> <td>Missing</td> <td>6</td> </tr> <tr> <td>Mean</td> <td></td> <td>3.73</td> </tr> <tr> <td>Median</td> <td></td> <td>3.00</td> </tr> <tr> <td>Mode</td> <td></td> <td>3</td> </tr> <tr> <td>Minimum</td> <td></td> <td>2</td> </tr> <tr> <td>Maximum</td> <td></td> <td>7</td> </tr> <tr> <td rowspan="3">Percentiles</td> <td>25</td> <td>3.00</td> </tr> <tr> <td>50</td> <td>3.00</td> </tr> <tr> <td>75</td> <td>4.25</td> </tr> </table>	N	Valid	22		Missing	6	Mean		3.73	Median		3.00	Mode		3	Minimum		2	Maximum		7	Percentiles	25	3.00	50	3.00	75	4.25
N	Valid	22																											
	Missing	6																											
Mean		3.73																											
Median		3.00																											
Mode		3																											
Minimum		2																											
Maximum		7																											
Percentiles	25	3.00																											
	50	3.00																											
	75	4.25																											
<p>2 - The type of transducer line used is</p> <ul style="list-style-type: none"> • 21/28 used an open transducer line • All units who used a closed line were Level 2 or 3 ICU 	<p>Open line with 3 way tap to access & then discard blood</p> <p>Closed line (blood conservation set)</p>																												
FLUSH SOLUTIONS																													
<p>3 - The flush fluid used to prime and maintain patency of the transducer line is</p> <ul style="list-style-type: none"> • Normal saline is the predominant solution with 25/28 units using it. • Only 4 units heparin: 2 units - 1000 in 500mls, 1 unit - 1 unit per ml, 1 no answer 	<ul style="list-style-type: none"> • Normal saline – 22/28 • 5% dextrose – 2/28 • Heparin Saline 3/28 (1 missing) 																												
<p>4 - Do you routinely use heparin in your flush solution (if yes please specify concentration)?</p>	<p>Yes – 4/28</p>																												
<p>5 - How often is the flush fluid changed?</p> <ul style="list-style-type: none"> • Dominant practice is to change the flush bag solution on a daily basis 	<ul style="list-style-type: none"> • 22/28 (78.6%) Daily • 2/28 (7%) - 3 days • 3/28 (10.7%) - PRN • 1/28 - 3-4 days 																												
DRESSINGS																													
<p>6 - How often are arterial line dressings changed?</p> <ul style="list-style-type: none"> • PRN dressing changes were most frequently nominated 	<ul style="list-style-type: none"> • 14/28 (50%) PRN • 4/28 (10.7%) - 3 days + prn • 2/28 (7.1%) - 2 days • 1/28 2 days + prn • 3/28 - 3 days 																												
<p>7 - What solutions are used to clean the arterial line site (more than one option can be ticked)?</p>	<ul style="list-style-type: none"> • 17/28 (60.7%) - 2% CHX in alcohol • 3/28 - 0.5% CHX in 70% alcohol • 2/28 - Betadine • 2/28 - Saline • 1 persist plus 																												
<p>8 - What type of dressing is most commonly used to dress arterial lines?</p> <ul style="list-style-type: none"> • 	<ul style="list-style-type: none"> • IV 3000 19/28 – 67.9% • Tegaderm 5/28 – 17.9% • Both IV 3000 and tegaderm – 2/28 • No answer 2/28 																												
GENERAL																													
<p>9 - What method is routinely used to secure the arterial catheter?</p>	<ul style="list-style-type: none"> • 13/28 (46%) - Stitch only • 5/28 (17.9%) Sterile tape plus stitch • 6/28 (21.4%) Taping with sterile tapes (eg steri strips) • 4/28 (14.3%) Stat lock 																												

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