The Use of Midline Catheters in the Adult Acute Care Setting – Clinical Implications and Recommendations for Practice

Evan Alexandrou, Lucie M. Ramjan, Tim Spencer, Steven A. Frost, Yenna Salamonson, Patricia M. Davidson, Ken M. Hillman

Abstract

***Aim and objectives**: The aim of this paper was to review published manuscripts on the use of midline catheters, the implications of study findings and recommendations for clinical practice in the acute care setting.*

***Design**: Modified integrative literature review*

***Methods**: Using key MeSH terms, we searched the electronic databases: CINAHL, Medline, and Embase. The Cochrane and Joanna Briggs databases, Google Search Engine and the reference lists of published materials were also searched. Studies were included if they were in the English language and reported the use of midline catheters in adult acute care populations. Manuscripts that described midlines made of aquavene were excluded*

***Results**: Two hundred and thirty two (232) papers were identified using the search strategy. From these identified papers, thirty (30) were included in the final review. Thematic analysis identified three major themes. These included: (i) advantages of using midline catheters (ii) disadvantages of using midline catheters (iii) insertion and management issues.*

***Conclusion**: Midline catheters have both positive and negative implications for clinical practice. They can be used for extended periods of intravenous therapy without requiring repeated cannulations but are not without risk. Midline catheters have been associated with mechanical and chemical phlebitis along with intravascular thrombosis. As such they are not suitable across the entire adult acute population. Midline catheters reduce the number of repeated cannulations which reduces patient discomfort, increases patient satisfaction and also contributes to organisational efficiency.*

Introduction:

The midline catheter (MC) is a vascular access device (VAD) that is approximately 20cm in length and is typically inserted into upper peripheral veins, above or below the antecubital crease (Anderson, 2004, 2005; Rosenthal, 2008). The MC is not used as a central venous catheter (CVC) in the adult population; this is because the tip of the MC is normally situated at or below the axillary vein and not in the central venous circulation (Anderson, 2004, 2005; Griffiths, 2007; Rosenthal, 2008).

The predominant uses of MCs have been limited to specialist vascular access teams (Anderson, 2004; Intravenous Nurses Society [INS], 1997). They were first introduced to the clinical setting in the 1950's (Vanek, 2002) and have since been marketed as a medium to long term indwelling catheter for the administration of intravenous fluids for hydration, certain antibiotics and continuous intravenous medication infusion (Griffiths, 2007; INS, 1997).

Materials used (such as Aquavane – an elastomeric hydrogel that softens and expands once in the blood stream giving it silicone like consistency) in the manufacture of some MCs caused concern in the 1990s as some patients developed hypersensitivity reactions to the catheter material (Goetz et al., 1998; Vanek, 2002, Myers and Kyle, 1993). This resulted in some device companies discontinuing the manufacture of MCs and their popularity subsequently declined.

Midline catheters have the potential to be used widely in the adult acute care population but this is yet to be established, with few outcome studies examining the use of MCs in the acute care setting (Griffiths, 2007). The aim of this study was to undertake a review of the literature to ascertain the implications for clinical practice in the adult acute care setting of the insertion and use of MCs. In particular, our goal was to review which acute care population groups would benefit most from MC placement, what complications are associated with this VAD and when are they an alternative to a peripheral cannula or a peripherally inserted central catheter (PICC) and CVC.

Correspondence concerning this article should be addressed to E.Alexandrou@uws.edu.au
DOI: 10.2309/java.16-1-5

Methods

A health care librarian with expertise in clinical literature reviews was consulted. The electronic databases CINAHL, Medline, Embase along with the Cochrane and Joanna Briggs databases were searched using key MeSH terms that included 'Catheterization', 'Peripheral', 'Central Venous', 'Catheters', 'Indwelling', 'midline or mid-line'. The reference lists of published materials were searched for additional literature. The World Wide Web was also searched using the Google Scholar search engine for related electronic documents.

An integrative review method was used because of the heterogeneity of the reviewed studies. An integrative review is a research method that allows for the inclusion of varying designs and it can provide a better understanding of the topic of interest (Whittemore & Knafl, 2005). Integrative reviews are beneficial in scoping a problem and documenting benefits for clinical practice.

Studies were included in this review if they described the use of MCs in the adult acute care population, if they discussed the implications for clinical practice or if the studies described outcomes related to the use of MCs. We limited the search to the English language and in adult acute care populations. Manuscripts describing Aquevene-based MCs were also excluded from this review as they discussed issues with manufacturing material for MCs. In light of heterogeneity and the aim to review the clinical implications for the use of MCs, all published manuscripts whether using experimental or non-experimental methods were included in the review. All articles meeting the search criteria were reviewed by the primary author and two co-authors using a critical appraisal tool (National Health Service, 2007).

Results

A total of 232 papers were identified using the search strategy described. The majority of papers did not discuss the use of MCs. Abstracts were reviewed by the authors (EA, LMR) to assess whether the papers met the inclusion criteria. This process identified thirty (30) papers that met the inclusion criteria. Included papers were then reviewed by the co-authors to confirm that they met the inclusion criteria. Following a thematic analysis, three themes emerged from this review relating to: (i) advantages of using midline catheters (ii) disadvantages of using midline catheters (iii) insertion and management issues. These are discussed below:

Advantages of using midline catheters:

The insertion of a MC avoids unnecessary repeated peripheral cannulation that may be required whilst hospitalised (Anderson, 2004; Griffiths, 2007; Rosenthal, 2008) and can be inserted by accredited specialist nurses (Griffiths, 2007; INS, 1997; Klein & Metules, 2001; Mermel, Parenteau & Tow, 1995). This is not only cost-effective for the institution but less traumatic for the patient and has the potential to avoid iatrogenic effects such as infection (Gorski & Czaplewski, 2004; Larouere, 2000a; Rosenthal, 2008; Smeed, 1990; Sterba, 2001) and minimises needle stick injuries for nurses (Mermel, Parenteau & Tow, 1995; Thomson, 1993). Anderson (2005) suggests that the cost of inserting an MC is the equivalent of approximately three peripheral cannulas (although no financial analysis data was shown). As such MCs can contribute to improving organisational efficiency by decreasing multiple cannulation due to compromised venous access (Anderson, 2005). Nurses experience less stress and save time when the need to re-cannulate a patient is avoided (Thomson, 1993).

Many advocate that MCs are ideally suited to patients requiring medium to long term intravenous (IV) therapy (Griffiths, 2007; INS, 1997; Kupensky, 1998). The Intravenous Nurses Society (1997) report that MCs ideal dwell time is 2-4 weeks however this time frame could be extended based on a nurse's professional assessment and judgement. Anderson (2005) suggests that the MC should be used for a patient requiring treatment for at least 5 days but no more than 28 days. Others propose a maximum dwell time of between 1-6 weeks but suggest 2-4 weeks in principle is optimal (Gorski & Czaplewski, 2004). Recent data suggest that up to 296 days is possible (Griffiths & Philpot, 2006, cited in Griffiths, 2007).

It is widely acknowledged that MCs can be used to administer intravenous medication or hydrating fluids that would normally be administered via a peripheral cannula but with the added benefit of delivering these in a bigger diameter vessel within the venous circulation (Anderson, 2005; Griffiths, 2007; INS, 1997). This increased vessel diameter (6-8mm) facilitates a greater flow rate of blood at the catheter tip, ensuring adequate dilution of medications (Hadaway, 2000; Rosenthal, 2008). This dilution reduces the incidence of chemical phlebitis, infiltration and patient discomfort during drug administration (Anderson, 2004, 2005; Gorski & Czaplewski, 2004; Lawson, 1998; Myers and Kyle, 1993). The MC can tolerate isotonic medications and solutions (250-350mEq/L) (Rosenthal, 2008), drugs and solutions with a pH level between 5 and 9, with a low osmolarity (<600mOsm) (Anderson, 2005; Klein & Metules, 2001; Rosenthal, 2008; INS, 2006) or blood products (Kupensky, 1998). Additionally, the 5Fr midline catheter can tolerate high flow rates with the aid of a pump (Vygon, 2006, cited in Griffiths, 2007).

Further advantages of MCs are that once inserted, they can be used without X-ray confirmation due to its final tip position being at or below the axillary vein (Gorski & Czaplewski, 2004; Griffiths, 2007; Vanek, 2002). However, the INS (1997) recommends that radiological confirmation be obtained if there are any of the following concerns: difficulty with advancing the catheter, impaired blood return, resistance to flushing, issues with guide-wire removal or patient distress following or during catheter insertion.

The need for heparin flushing can also be eliminated as some MCs are manufactured with pressure displacement valves, these valves will only open if positive or negative pressure is applied. Thus a closed valve system assists in maintaining catheter patency by inhibiting retrograde flow of blood or air, decreasing the chance of occlusion or thrombus formation (Griffiths, 2007).

Although this study pertains to MCs in the adult acute care population, MCs are ideal for patients of all ages with an uncomplicated medical history, which can facilitate early discharge into less costly community care such as home IV antibi-

otic programs (Griffiths, 2007). Midline catheters also provide the ability to be used for the older adult with compromised venous access or chronic and complex medical issues (Anderson, 2005; Griffiths, 2007; Rosenthal, 2008; Sterba, 2001). Midline catheters have a low infection rate comparable to the infection rate of PICCs (Maki, Kluger & Crnich, 2006; Vanek, 2002). Some authors have reported a decrease in the rate of infection with increased dwell times for MCs as opposed to other vascular access devices (VADs) such as peripheral cannulas (Mermel, Parenteau & Tow, 1995). This has been supported by the Center for Disease Control [CDC], (2002) which reported MCs have lower rates of phlebitis than do peripheral cannulas. Decreased bacterial counts on the skin over the antecubital region where midlines are inserted, in comparison to areas over the chest and neck, where CVCs are inserted have been reported to be possible factors in the low incidence of catheter related infections (Lawson, 1998).

Disadvantages of using midline catheters:

The risk of extravasation can be high with the use of MCs due to potential positioning of the catheter tip in the axillary vein. This can put other anatomical structures at risk such as damage to arteries and nerves if extravasation goes undetected (Hadaway, 2000). Midline catheters are not recommended for the infusion of dextrose solutions >10% (Rosenthal, 2008), vesicants (Anderson, 2005; Hadaway, 2000; Rosenthal, 2008) and potent antibiotics, such as vancomycin (Anderson, 2005; Klein & Metules, 2001; Rosenthal, 2008). In these cases a CVC or PICC is preferable due to the deeper catheter tip position. Gravity administration is not always a viable option and in most cases a pump is required to deliver medications and fluids at higher infusion rates (Griffiths, 2007).

The most common complication with MCs is mechanical phlebitis (Anderson, 2004; Rosenthal, 2008). The trauma caused to the vessel wall may be as a result of frequent manipulation of the midline catheter (Griffiths, 2007) and is generally evident a week post insertion of the line but can occur at any time while in use (Gorski & Czaplewski, 2004). In some instances, the phlebitis and discomfort can be relieved with the use of warm compresses, elevation and use of analgesia (Carlson, 1999; Gorski & Czaplewski, 2004; Larouere, 2000b).

The catheter is unsuitable for patients with compromised anatomy and conditions such as lymphoedema, or who have had previous infection or phlebitis to the arm being considered (Griffiths, 2007).

Insertion and Management Issues:

A thorough patient vascular and clinical assessment needs to be undertaken prior to the insertion of an MC. This includes reviewing past medical and surgical history including history of radiotherapy, lymph oedema, upper arm surgery or trauma and visualisation of any areas of bruising, scarring and infection from previous cannulation (Griffiths, 2007). A vascular assessment should be undertaken to ensure vessel patency, identify any thrombosis, and assess the diameter of vessel to be cannulated. This assessment ideally should incorporate the use of ultrasound technology (INS, 2006; Pittiruti et al., 2009).

According to Griffiths (2007) MC placement is a nursing responsibility and "nurse-led procedure", as specialist nurses who are competency verified are best suited to assessing patients' needs and vascular access requirements (p. 57). In agreement, Anderson's (2004, p.318) study of the Evangelical Community Hospital's (Pennsylvania) use of midlines found that "midline placement became a decision based entirely on nursing evaluation...", unlike PICC placement which still required referral to a physician.

Midlines are inserted into the patient's non-dominant arm (Larouere, 2000a; Pittiruti et al., 2009), preferably with local anaesthetic and using strict aseptic technique and barrier precautions (Carlson, 1999; Pittiruti et al., 2009; Rosenthal, 2008). The point of insertion should be approximately 5cm above or below the antecubital crease (Griffiths, 2007). There is a significant risk of venous thrombosis if placement is above the axillary line (Gorski & Czaplewski, 2004).

The catheter is advanced into either the cephalic, basilic or median cubital veins of the antecubital fossa, until its tip sits at or below the axillary vein (Anderson, 2005; Gorski & Czaplewski, 2004; Griffiths, 2007; Larouere, 2000a). The larger diameter and more direct route of the basilic vein makes it the best option (Larouere, 2000a).

Griffiths (2007) described two predominantly used techniques for inserting MCs: the use of "a cannula with a peel-away sheath or the Seldinger technique using specific Seldinger insertion kits" (p. 50). The latter technique with ultrasound guidance is used for patients with compromised venous access (Griffiths, 2007). Once the midline is *in situ*, accurate documentation in the clinical notes should include length of catheter, vein used, follow-up instructions (Griffiths, 2007), patient tolerance of the procedure, difficulties encountered with insertion and brand and lot number of catheter (Carlson, 1999; Gorski & Czaplewski, 2004). Arm circumference (15cm above the insertion site) should be measured at least four times a day during a continuous infusion or before each individual dose to detect complications early (Larouere, 2000b).

Policies differ in regard to dressing, line changes and flushing technique. Aseptic technique is required when caring for midlines (flushing, dressing, infusate administration set changes) (Burns, 2006; Kupensky, 1998). The majority of policies suggest that the MC dressing be changed 24 hours post-insertion and then weekly thereafter, unless the dressing is compromised (Anderson, 2005; CDC, 2002; Griffiths, 2007). The catheter should be secured to prevent migration and should be checked daily for excess moisture, bleeding, tenderness or other complications (Anderson, 2005; CDC, 2002; Gorski & Czaplewski, 2004; Griffiths, 2007). Gorski and Czaplewski (2004) report that there is uncertainty in regard to the securement device of choice but suggest that the manufactured devices are less problematic. The three methods of securing a midline include sutures, sterile tape strips and manufactured adhesive securement devices (Gorski & Czaplewski, 2004).

Site care should always be conducted using an aseptic technique and includes skin disinfection, dressing change and if necessary a change of the securement device (Gorski & Czaplewski, 2004). The CDC (2002) prefers 2% chlorhexidine

gluconate with 70% isopropyl alcohol as the most effective skin antiseptic for preventing catheter-related infections. It is applied easily (for 30 seconds), has a quick effect (dries within 30 seconds), and provides a 6 hour microbial protection (Gorski & Czaplewski, 2004).

Gauze or transparent dressings are options. However, transparent dressings are optimal as they allow visualisation of the exit site, can remain insitu for a week (CDC, 2002; Griffiths, 2007; Klein & Metules, 2001) and possess high permeability properties, keeping the site dry (CDC, 2002). Gauze dressings, on the other hand, should be changed at least every 2 days, if daily is not possible, and are more difficult to inspect thoroughly without removal of the dressing (CDC, 2002; Gorski & Czaplewski, 2004, Klein & Metules, 2001).

Infusate administration sets should occur every 3-7 days (Anderson, 2005) and the CDC (2002) recommends changing infusion sets no more often than 72hrs unless clinically indicated. Extension sets and lines should be replaced within 24 hours following the administration of blood or lipid products (CDC, 2002).

A syringe size of at least 10mL is used to flush the midline with a pulsating action (push-pause-push) at least daily if not heparin locked to avoid occlusions and maintain patency (Anderson, 2005; Gorski & Czaplewski, 2004; Griffiths, 2007). The flushing solution of choice is 10mL of sterile normal saline (Anderson, 2005; Sterba, 2001). The same syringe sizes are used to administer drugs as a push to avoid excess pressure and possible rupture of the catheter (Anderson, 2005; Gorski & Czaplewski, 2004; Griffiths, 2007). Gorski and Czaplewski (2004) recommend the SASH method (saline, administer medication, saline, heparin lock) with drug administration to avoid complications associated with the mixing of the drug with heparin. Small amounts (1mL) of heparin (100units/mL) are used to prevent thrombotic occlusions (Anderson, 2005). Positive pulsatile pressure flushing and lock technique can be used to prevent retrograde flow of blood back into the catheter and also minimises the development of a fibrin tail or eventual fibrin sheath formation (Sterba, 2001).

To conserve the MC, blood pressure cuffs and tourniquets should not be applied above the midline site (INS, 2006; Rosenthal, 2008).

Institutional issues with midlines include the lack of trained, experienced staff that are able to insert midlines and in some cases lack of patient consent or compliance with devices (Griffiths, 2007).

Discussion

Implications for clinical practice

Midline catheters are a viable and feasible option for adults in an acute care setting, who require intermediate to long-term intravenous therapy (Griffiths, 2007; INS, 1997). Recommended dwell times average 2-4 weeks. However, MCs can be used for longer periods without complications (INS, 1997). The longer dwell time of the MC in comparison with a peripheral cannula (96hrs) (CDC, 2002) is appealing to patients as it reduces the number of repeated cannulations that may be required while hospitalised (Anderson, 2004; Griffiths, 2007; Rosenthal, 2008), reduces the likelihood of compromise, and patient anxiety is reduced (Smeed, 1990).

Midline catheters should be inserted by suitably qualified and accredited registered nurses and registered physicians (INS, 1997; Kupensky, 1998; Rosenthal, 2008). These individuals should be accredited and their competency verified through the completion of formal educational programs, including theoretical and practical components. (Burns, 2006; Carlson, 1999; Gorski & Czaplewski, 2004, INS, 1997; Rosenthal, 2008). Burns (2006) indicates that there should be four phases in the training process: observing the process, assisting with insertions, observed catheter insertion with assistance, and independent insertion. The CDC (2002) states that dedicated "IV teams" are a factor in the minimisation of catheter related infections and institutional costs. A recent study comparing the insertion of CVCs between a dedicated nurse-led team and anaesthetic medical staff showed favourable insertion and infection outcomes for the nurse led team (Yacopetti et al. 2010).

There are many patient cohorts where a MC can facilitate both early discharge from hospital and care at home, thereby increasing patient satisfaction (Griffiths, 2007). These patient cohorts include those with Stage 4 Congestive heart failure needing IV frusemide boluses and patients requiring IV antibiotics for different types of infections who can be treated at home by specialist community nurses or within an outpatient setting (Griffiths 2007).

Small research studies have shown that midlines have been used successfully for patients with Acquired Immune Deficiency Syndrome (AIDS) receiving home IV therapy (Smeed, 1990). In retrospect, Sargent and Nixon's (1997) study of 12 MCs and 18 PICCs found that PICCs were a better alternative for the treatment of patients with AIDS and cytomegalo virus (CMV) disease with their study participants preferring a PICC in the future (although this was possibly due to a change in treatment protocol during the study period).

Midlines reportedly have been used for the administration of non-vesicant medication and fluids to critically ill patients (Griffiths, 2007). They also have proven to be effective in the elderly patients or patients with difficult venous access (Anderson, 2005; Griffiths, 2007; INS, 1997; Rosenthal, 2008; Sterba, 2001).

Recommendations for Clinical Practice

Midline catheters are not suitable for patients with a history of thrombosis, hypercoagulopathy, medical conditions that impede venous flow from the extremity (i.e paralysis, lymphoedema, orthopaedic, neurologic conditions) and patients undergoing dialysis who have an AV fistula (Larouere, 2000a). Patient preference is also important and the patient should participate in the determination of whether the midline is best suited to their needs, taking into consideration their activity levels and purpose of treatment (Gorski & Czaplewski, 2004; INS, 1997). These recommendations for practice are summarised in Table 1.

Although a range of drugs and solutions can safely be infused through a MC, the majority of administration guidelines indicate that midlines should not be used to administer vesicants such as continuous chemotherapy (Anderson, 2005; Banton & Leahy-Gross, 1998; Hadaway, 2000; INS, 1998, 2000;

Larouere, 2000a; Rosenthal, 2008) or dopamine (Anderson, 2005; Banton & Leahy-Gross, 1998; Rosenthal, 2008) as these agents can cause tissue damage and chemical phlebitis (Hadaway, 2000). In addition, most of the literature reveals that MCs do not tolerate and are not safe for the delivery of solutions such as total parenteral nutrition (TPN), solutions with greater than 10% dextrose or greater than 5% protein (INS, 2000) and drugs with a pH<5 or >9 or with an osmolality >600mOsm/L (INS, 2006; Larouere, 2000a). Drugs and electrolytes not suited to midlines include vancomycin (Anderson, 2005; Banton & Leahy-Gross, 1998; Hadaway, 2000), phenytoin, (Banton & Leahy-Gross, 1998; Klein & Metules, 2001; Rosenthal, 2008), calcium, potassium, nitroprusside, promethazine (Hadaway, 2000) and rapid, large volume infusions or high pressure boluses (Larouere, 2000a).

Rosenthal (2008) clearly outlines that midlines can safely administer isotonic drugs and solutions (250-350mEq/L), plain fluids, drugs and solutions with a pH between 5 and 9, cephalosoporin antibiotics, and antifungals such as amphotericin B (Ambisome). Heparin also can be safely administered via a midline (Anderson, 2004, 2005).

Additionally, Pittiruti and colleagues found that midlines, placed under ultrasound guidance, were safe for the administration of parenteral nutrition with an osmolarity <800mOsm/L and had minimal complications, although it must be noted that the study sample size was small - 94 midlines inserted for patients requiring >10 days of parenteral nutrition (Pittiruti et al., 2009). Guidelines suggest that midlines should be used sparingly to administer parenteral nutrition, osmolarity should be less than 850mOsm/L and vigilant monitoring is essential (Pittiruti, Hamilton, Biffi, MacFie & Pertkiewicz, 2009). Matsumoto, Shirotani and Kameoka (1999) agree that midline catheters are safe for the administration of parenteral nutrition, optimally with an osmolarity ratio of 3.1 or less and glucose/fat ratio 1:2.

Another study demonstrated that fine bore midlines can be safely used to administer peripheral intravenous nutrition and that the addition of heparin prolonged feeding times, but there remains public concerns for the use of heparin as a feeding additive and further studies are needed (Catton et al., 2006).

Strengths and Limitations:

One clear limitation of this review is that we found only a small number of outcome based studies showing the effectiveness of MCs. Most papers were narrative in nature and quasi-experimental in design. We excluded papers or studies that were not in English or not in the adult population; this may have prevented the authors from reviewing potential articles of interest. Despite these limitations, this review was undertaken in a prospective and systematic way and as such encapsulates the majority of papers and studies describing the use of MCs in adult care settings.

Conclusion

This literature review was undertaken to ascertain the implications for clinical practice in the adult acute care setting of the insertion and use of MCs. The review has highlighted that MCs have a role to play in many patient cohorts and can be used as an alternative to multiple peripheral cannulations.

In some cases, there is a potential for MCs being used in place of a PICC or CVC in order to reduce risk of insertion complications and the need for a chest x-ray. An MC can be a replacement for peripheral IV cannulas and can potentially improve organisational efficiencies by reducing work load demands on clinicians inserting VADs. Midline catheters can also be used to facilitate early discharge from hospital for patients who can be treated in community settings rather than remaining in hospital for treatment. This can lead to improved patient satisfaction and potential cost savings (Griffiths, 2007).

Although the use of MCs can deliver many benefits, there are also disadvantages to consider. Midline catheters have been associated with mechanical and chemical phlebitis and are not suitable for patients with abnormal compromised venous circulation. Midline catheters are suitable only for patients who require short to intermediate therapy up to 4 weeks in general. If longer treatment is required, a PICC or CVC is more suitable.

Overall, MCs offer many potential advantages. They can be used in a variety of acute care settings where multiple peripheral cannulas traditionally have been used or as a replacement for a PICC or CVC.

Table 1. **Recommendations for Placing Midline Catheters in the Adult Acute Care Setting**

Recommendations for insertion:
• Use strict aseptic technique and maximal barrier precautions.
• Insert under ultrasound guidance above the ante cubital crease.
• Basilic vein preferable.
• Catheter distal tip should be at or below the axillary vein.
Recommendations with therapy:
• Ideal for IV therapy lasting between 2 – 4 weeks.
• Use with near isotonic solutions (250-350mEq/L).
• Medication pH should be no less than 5 or exceed 9.
• Good for elderly patients with limited venous access.
• Fluids with osmolality <600mOsm/L (However, up to 800mOsm/L has been cited by Pittiruti et al., 2009)
Special considerations for midline use:
• Patients at risk of thrombosis.
• Patients with compromised circulation.
• Patients at risk of lymph oedema.
• Patients with end stage renal disease requiring vein preservation.

AUTHORS' CONTRIBUTIONS EA, LMR and TS planned and conducted the review; SAF, YS and PD assisted in the review of the literature and manuscript formation. All other authors had an active role in data interpretation. All authors contributed to the final manuscript.

ACKNOWLEDGEMENT:

The authors wish to thank Ms Karen Andrews, health librarian and manager at Liverpool Hospital NSW Australia for her assistance in the literature review.

References

Anderson, N. R. (2004). Midline catheters: The middle ground of intravenous therapy administration. *Journal of Infusion Nursing*, *27*(5), 313-321.

Anderson, N. R. (2005). When to use a midline catheter. *Nursing2005*, *35*(4), 68.

Banton, J., & Leahy-Gross, K. (1998). Assessing catheter performance: Four years of tracking patient outcomes of midline, midclavicular and PICC line program. *Journal of Vascular Access Devices, 3*(3), 19-25.

Burns, D. F. (2006). Developing a successful radiology nursing peripherally inserted central catheters and midline insertion program. *Journal of Radiology Nursing*, *25*(4), 116-118.

Carlson, K. R. (1999). Correct utilization and management of peripherally inserted central catheters and midline catheters in the alternate care setting. *Journal of Intravenous Nursing*, *22*(6), 46-50.

Catton, J. A., Davies, J., Dobbins, B. M., Wood, J. M., McMahon, M. J., & Burke, D. (2006). The effect of heparin in peripheral intravenous nutrition via a fine-bore midline: A randomised double-blind controlled trial. *Clinical Nutrition*, *25*, 394-399.

Centers for Disease Control and Prevention [CDC]. (2002). Guidelines for the prevention of intravascular catheter-related infections. *MMWR*, *51*(RR-10), 1-31.

Goetz, A. M., Miller, J., Wagener, M. M., & Muder, R. R. (1998). Complications related to intravenous midline catheter usage: A 2-year study. *Journal of Intravenous Nursing*, *21*(2), 76-80.

Gorski, L. A., & Czaplewski, L. M. (2004). Peripherally inserted central catheters and midline catheters for the homecare nurse. *Journal of Infusion Nursing*, *27*(6), 399-409.

Griffiths, V. (2007). Midline catheters: Indications, complications and maintenance. *Nursing Standard*, *22*(11), 48-57.

Hadaway, L. (2000). Catheter connection: Can midline catheters be used to infuse vesicant medications? *Journal of Vascular Access Devices*, *5*(1), 41.

Intravenous Nurses Society [INS]. (1997). Position paper: Midline and midclavicular catheters. *Journal of Intravenous Nursing*, *20*(4), 175-178.

Intravenous Nurses Society [INS]. (2006). Infusion nursing standards of practice: Site selection and device placement. *Journal of Infusion Nursing*, *29*(1S), S37-S39.

Klein, T., & Metules, T. J. (2001). PICCs and midlines: Fine-tuning your care. *RN*, *64*(8), 26-29.

Kupensky, D. T. (1998). Applying current research to influence clinical practice: Utilization of midline catheters. *Journal of Intravenous Nursing*, *21*(5), 271-274.

Larouere, E. (2000a). I.V. Rounds: Placing a midline catheter. *Nursing2000*, *30*(3), 26.

Larouere, E. (2000b). I.V. Rounds: Managing a midline catheter. *Nursing2000*, *30*(4), 17.

Lawson, T. (1998). Infusion of IV medications and fluids via PICC and midline catheters: Influences of tip position on the success of infusion. *Journal of Vascular Access Devices*, *3*(2), 11-17.

Maki, D. G., Kluger, D. M., & Crnich, C. J. (2006). The risk of bloodstream infection in adults with different intravascular devices: A systematic review of 200 published prospective studies. *Mayo Clinic Proceedings*, *81*(9), 1159-1171.

Matsumoto, M., Shirotani, N., & Kameoka, S. (1999). Clinical study on the ratio of glucose/fat in peripheral parenteral nutrition and the usage of a midline catheter. *Surgery Today*, *29*(10), 1040-1046.

Mermel, L. A., Parenteau, S., & Tow, S. M. (1995). The risk of midline catheterization in hospitalized patients: A prospective study. *Annals of Internal Medicine*, *123*(11), 841-844.

Myers, J. S., & Kyle, S. K. (1993). Intermediate-term intravenous therapy: A pilot study. *Journal of Post Anaesthesia Nursing*, *8*(1), 21 – 25.

National Health Service (2007). Critical appraisal skills programme (CASP) and
evidence-based practice. Public Health Resource Unit - Oxford, United Kingdom.

Pittiruti, M., Hamilton, H., Biffi, R., MacFie, J., & Pertkiewicz, M. (2009). ESPEN guidelines on parenteral nutrition: Central venous catheters (access, care, diagnosis and therapy of complications). *Clinical Nutrition*, *28*(4), 365-377.

Pittiruti, M., Scoppettuolo, G., Emoli, A., Dolcetti, L., Migliorini, I., Lagreca, A., & Malerba, M. (2009). Parenteral nutrition through ultrasound-placed PICCs and midline catheters is associated with a low rate of complications: An observational study. *Nutritional Therapy & Metabolism*, *27*(3), 142-148.

Rosenthal, K. (2008). Bridging the I.V. access gap with midline catheters. *Med/Surg Insider*, *2*, 4-5.

Sargent, J., & Nixon, E. (1997). IV access options for AIDS patients with cytomegalovirus disease. *British Journal of Nursing*, *6*(10), 543-553.

Smeed, C. (1990). Use of a midline catheter in PWAs. *AIDS Patient Care*, *4*(3), 34-37.

Sterba, K. G. (2001). Controversial issues in the care and maintenance of vascular access devices in the long-term/subacute care client. *Journal of Infusion Nursing*, *24*(4), 249-254.

Thomson, S. (1993). IV therapy: A financial feasibility study. *Nursing Management*, *24*(6), 68A-68B, 68D, 68F-68G.

Vanek, V. W. (2002). The ins and outs of venous access: Part 1. *Nutrition in Clinical Practice*, *17*(2), 85-98.Vascular Access Device Selection, Insertion and Management. Salt Lake City,Utah: Bard Access Systems 2002

Yacopetti, N., Alexandrou, E., Spencer, T. R., Frost, S. A., Davidson, P. M., O'Sullivan, G., & Hillman, K. M. (2010). Central venous catheter insertion by a clinical nurse consultant or anaesthetic medical staff: a single-centre observational study. *Critical Care and Resuscitation*,*12*(2),90-95.

Whittemore, R., & Knafl, K. (2005). The integrative review: Updated methodology. *Journal of Advanced Nursing, 52*, 546-553.