

School of Nursing and Midwifery

**Towards Best Practice: Procedural Characteristics and
Outcomes of Nurse-Led Central Venous Catheter Insertion**

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**This thesis is presented for the Degree of
Doctor of Philosophy
of
Curtin University**

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DECLARATION:

“To the best of my knowledge and belief this thesis contains no material previously published by any other person except where due acknowledgement has been made. This thesis contains no material which has been accepted for the award of any other degree or diploma in any university”.

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Date: 17th November 2013

ABSTRACT

Background: Central venous catheters are essential for the parenteral delivery of many vesicant and increased osmolar medications that are not suited for peripheral administration. This may include the critically ill requiring vaso-active medication, patients requiring parenteral nutrition or where medical therapy requires extended periods of access to the venous circulation.

The traditional role of the medical practitioner solely providing central venous catheterisation is increasingly being challenged, largely due to clinical specialisation and medical staff shortages. Lack of procedural exposure can lead to adverse procedural outcomes from central venous catheter placement or latent catheter related bloodstream infection resulting in increased length of hospital stay and increased morbidity and mortality risk.

Central venous catheter placement by advanced practice nurses has up until recently been largely viewed as a unique approach to providing central venous access for patients, rather, than being considered as an alternative to improving patient safety and organisational efficiency. Although information on procedural outcomes from nurses placing peripherally inserted central catheters is common, there is a paucity of such data on central venous catheter placement.

Objectives: The intention of this thesis is to observe and report on the procedural outcomes of trained nurse specialists who insert central venous catheters and provide evidence for an expanded nursing role in this specialty. The thesis will substantiate that specialist nurses inserting such devices can critically synthesise patient assessment and insert different vascular devices for different therapeutic purposes to suit patient need. Research findings have been submitted to peer reviewed journals during the time of candidature. The published studies will support the argument that appropriate training, credentialing and procedural volume are better determinants for influencing device and patient outcomes rather than clinician grade.

Methods: This thesis comprises six separate studies investigating characteristics of nurse led central venous catheter placement as an approach to improve patient safety and healthcare efficiency. These six manuscripts provide supporting evidence that this pragmatic approach to central venous access can provide efficient catheter placement whilst minimising insertion complications and catheter related blood stream infection. All six published studies have discrete methodology pertinent to the investigation. The methodology was chosen within the context of availability of primary or meta data.

A systematic review method was chosen for 2 studies which involved scoping published literature to synthesise outcomes of interest. An integrative review method was required due to the inclusion of manuscripts with varying research designs that were both experimental and non-experimental in nature; this process provided a holistic review of the topic of interest. An integrative review method can be beneficial in scoping of a problem or issue and empirically documenting a plan of action when considering implications for policy, practice and research.

One study used a retrospective analysis of archival administrative information that included reports and minutes of departmental meetings on the genesis of a nurse led central venous catheter insertion service. A process evaluation method was used that incorporated thematic analysis so that information of interest could be interpreted and synthesised into categories and characteristics that influenced the acceptance of nurse led central venous catheter placement.

The remaining 3 studies reported primary data on the characteristics of advanced practice nurses inserting central venous catheters from different centres. All three studies were observational in design and reviewed procedural complications and catheter related blood stream infection rates. All six studies were limited to adult populations and in the case of the observational studies, were conducted in hospitals in New South Wales, Australia. Ethical approvals for the studies were gained as required and overall ethical approval for this thesis was also granted.

Results: The series of studies conducted in this thesis established that training specialist nurses to provide such advanced practice can facilitate standardising of care and improving surveillance of catheters, provide earlier catheter placement and possibly improve the training and accreditation process for junior medical officers in central venous catheter placement. Approval for nurses to insert central venous catheters was generally a response to increased medical officer workload, delays in catheter placement and treatment, and the lack of supervision of junior medical officers inserting these devices which led to unacceptable risk. Training and credentialing formed a core component for nurses providing such a service whereby learning programs were locally based but included theory, clinical teaching and competency based assessment that involved procedural volume.

An added advantage emerging from nurse led central venous access was the ability to tailor the device to patient need. As an exemplar, we reviewed the use of midline catheters in adult acute care settings. Midline catheters were not suitable across the entire population as they have been associated with mechanical and chemical phlebitis along with intravascular thrombosis; however they can reduce patient discomfort, increase patient satisfaction and also contribute to organisational efficiency by reducing the number of repeated peripheral cannulations.

The observational studies undertaken in this thesis did not demonstrate any difference in rates of adverse events from central venous catheters placed by advanced practice nurses compared to predominantly medically published literature. Data emerged that complication rates were either comparable or favourable to catheter catheters placed by medical officers. In one observational study conducted in this program that compared procedural outcomes between an advanced practice nurse and medical inserters, the rate of central venous catheters investigated for infection were twice as high in the medical staff group (19% v 8%) compared to the clinical nurse consultant and the confirmed catheter-related bloodstream infection (CRBSI) rate was 2.5/1000 catheters in the medical staff group and 0.4/1000 catheters for the clinical nurse consultant ($p = 0.04$).

In a separate study, the central line associated bacteraemia rate for catheters placed by nurses was lower in comparison to the medically placed central venous catheters [1.3 per 1000 catheters (95% CI = 0.03 – 7.3) vs. 7.2 per 1000 catheters (95% CI = 5.9 – 8.7)].

The final study reported on an established central venous catheter service, where a total of 4560 catheters were placed in 3447 patients over a 13 year period for a reported cumulative 63071 catheter days. The overall catheter related blood stream infection rate was 0.2 per 1000 catheter days. The incidence rate of pneumothorax recorded was 0.4% and accidental arterial puncture was 1.3% using the subclavian vein. The report demonstrated low complication rates for a hospital wide service delivered by advance practice nurses.

Conclusion:

Six discrete studies were carried out to validate nurse-led central venous catheter placement. The program of research undertaken in this thesis has shown that nurse-led catheter placement outcomes were equal and in some cases better than the wider literature that is predominantly medically published. This mode of service delivery can contribute many benefits to the health care sector that include improved quality of care, improved patient safety and satisfaction and a reduction in health care costs by reducing complications and improving efficiency through earlier catheter placement for more timely treatment.

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2. Alexandrou, E., Spencer, T., Frost, S.A., Parr, M., Davidson, P.M., Hillman, K.M. (2010). Establishing a nurse-led central venous catheter insertion service. *Journal of the Association for Vascular Access*, 15 (1), 21–27
3. Alexandrou, E., Ramjan, L., Spencer, T., Frost, S.A., Salamonson, Y., Davidson, P.M., Hillman, K.M. (2011). The use of midline catheters in the adult acute care setting – clinical implications and recommendations for practice. *Journal of the Association for Vascular Access*, 16 (1), 8–13.
4. 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.
5. Alexandrou, E., Murgo, M., Calabria, E., Spencer, T. R., Carpen, H., Brennan, K., Frost, S.A., Parr, M., Davidson, P.M., Hillman, K.M. (2011). Nurse-led central venous catheter insertion—Procedural characteristics and outcomes of three intensive care based catheter placement services. *International Journal of Nursing Studies*, 49(2), 162-168.
6. Alexandrou, E., Spencer, T., Frost, S. A., Mifflin, N., Davidson, P. M., & Hillman, K. M. (2014). Central venous catheter placement by advanced practice nurses demonstrates low procedural complication and infection rates – A report from 13 years of service. *Critical Care Medicine*, 42(2), 536-543.

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STATEMENT OF CONTRIBUTION OF OTHERS:

This is a doctoral dissertation by publication. A number of researchers have collaborated and contributed in part to the publications included within this thesis. The research design, data collection, data analysis and interpretation of study results, along with the preparation of the manuscripts was the examinee's work (co-author contributions are duly acknowledged). All jointly published manuscripts included in this thesis were undertaken with permission of the co-authors.

Contribution by the examinee and co-authors to each of the published papers included in this thesis is outlined in the proceeding pages.

Publication 1

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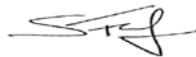
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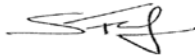
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Alexandrou, E., Ramjan, L., Murphy, J., Hunt, L., Betihavas, V., & Frost, S.A. (2012). Training of Undergraduate Clinicians in Vascular Access: An Integrative Review. *Journal of the Association for Vascular Access*, 17(3), 146-158.

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Betihavas, V., Newton, P. J., Frost, S.A., Alexandrou, E., Macdonald, P.S., & Davidson, P. (2013). Importance of Predictors of Rehospitalisation in Heart Failure: A Survey of Heart Failure Experts. *Heart, Lung and Circulation*. 22(3), 179 - 183.

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A Comparison of fluid installation volumes to assess intra-abdominal pressure using Kron's methods. (2012). *Journal of Trauma & Acute Care Surgery*. 73(1), 152-155.

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Alexandrou, E. (October 2011). Nurse-led central venous catheter insertion—Procedural characteristics and outcomes of three intensive care based catheter placement services. Paper presented at the Australian & New Zealand Intensive Care Society / Australian College of Critical Care Nurses: Annual Scientific Meeting, Brisbane, Australia.

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CHAPTER ONE

INTRODUCTION & OVERVIEW

Globally, there is an increased focus on health workforce issues and clinical outcomes. Extended nursing practice roles are seen as an important strategy for improving both organisational efficiencies and patient outcomes (Byers & Brunell, 1998; Cullum, Spilsbury, & Richardson, 2005; Ean et al., 2006). This thesis by publication is comprised of a series of discrete studies to investigate nurse led central venous catheter (CVC) placement as an approach to improve patient safety and healthcare efficiency (E. Alexandrou, Murgo, et al., 2011; E. Alexandrou, Ramjan, et al., 2011; Evan Alexandrou et al., 2014; E. Alexandrou et al., 2010a; E. Alexandrou et al., 2010b; Yacopetti et al., 2010).

Within the context of this thesis and also the published manuscripts, the term ‘nurse led’ relates to an advanced practice registered nurse who has received specialised training, has the procedural experience and knowledge to select and insert the most appropriate vascular access device (VAD) after undertaking a comprehensive patient assessment. The studies comprising this thesis have investigated the utility of this concept to improve procedural outcomes related to catheter insertion and to reduce the burden of catheter related blood stream infection (CRBSI) or central line associated bacteraemia (CLAB).

This chapter provides a contextual background on central venous access devices (CVADs) that include CVCs and peripherally inserted central catheters (PICCs). The chapter also highlights the short and long term complications from CVAD placement and provides an overview of the thesis, followed by a glossary of terms.

Background:

The earliest attempts at vascular access and intravenous therapy (IVT) have been documented as far back as 1492 when a physician caring for the Pope Innocent VIII, the 250th successor of the apostle Peter, suffered a stroke and had become increasingly ill, eventually falling into a coma. The physician attempted a blood transfusion by ‘giving’ the pontiff blood from three healthy youths in an attempt to save his life. No vascular access device was used, rather the vessels were anastomosed and blood was exchanged between the youths and the pontiff. This attempt was unsuccessful with all three youths and the Pope dying (Rivera, Strauss, Van Zundert, & Mortier, 2005).

Vascular access has evolved significantly since. Today, over 80% of hospitalised patients will require some form of IVT (Kaufman & Mary, 1992). It is estimated that in the United States (US), approximately 150 million vascular access devices will be purchased by health care facilities annually (Mermel et al., 2009). Vascular access has become the most commonly practiced procedures in the acute care setting with a significant proportion of clinical nursing work time allocated to these devices and related care (Casella & Jarvis, 2007).

Patient outcomes have improved significantly with advancements in technology and treatment. In parallel, the increasing complexity of patient co-morbidity and specialised procedural skills required to treat them has also attributed to adverse procedural outcomes (Barach & Johnson, 2006; Pronovost, Wu, Dorman, & Morlock, 2002). Central venous access device placement is one such procedural skill that has become an essential component to many therapies, yet carries procedural risk which can lead to serious adverse patient outcomes that can contribute to morbidity and mortality (Arenas-Marquez, Anaya-Prado, Barrera-Zepeda, & Gonzalez-Ojeda, 2001; Taylor & Palagiri, 2007).

Central venous access devices are commonly inserted for a number of therapeutic reasons that include antibiotic and chemotherapy administration, parenteral feeding and long term vascular access where peripheral cannulation is not suitable. Central venous access devices are also widely used in critical care areas for the administration of vasoactive medication and for haemodynamic monitoring (Dougherty, 2007).

The increasing demand for, and use of CVADs has concomitantly linked them as an attributable risk for hospital acquired infection (HAI) and have been implicated in contributing to patient adverse outcomes (Mermel et al., 2009). Optimal vascular access requires new and existing clinicians to be educated and skilled on the most appropriate device to be used, in the most appropriate vessel, for the patient for the most appropriate amount of dwell time (Weinstein, 2006).

Awareness of these factors, along with the use of evidenced based guidelines, has shown to decrease the incidence of CRBSI / CLAB, increase device longevity and improve patient health outcomes (Berenholtz et al., 2004; Warren et al., 2006). In Australia, approximately 3500 CLABs related to CVADs occur annually and have been associated with increased length of hospital stay and increased health care costs along with contributing to morbidity and mortality. A large proportion of these infections are deemed to be preventable (Department of Human Services, 2005).

Central Venous Access Devices:

Although peripheral cannulas are predominantly used for most hospitalised patients, some treatments required by patients preclude them from being used. This is because some intravenous medications and fluids can be very irritable to a peripheral vein which can lead to inflammation and infection (Hadaway, 2000; Hecker, 1989; Taylor & Palagiri, 2007). Medications that cannot be administered through a peripheral vein because of their viscosity, acidity or osmolarity are required to be given through a CVAD (Sauerland, Engelking, Wickham, & Corbi, 2006; Taylor & Palagiri, 2007).

The concept of a CVAD relates to the distal catheter tip terminating in the central circulation in the distal superior vena cava (SVC). Catheters that are inserted from the femoral vein and terminate in the inferior vena cava (IVC) are also termed CVADs but are not as widely used for long term therapy. As such, any catheter that terminates in the distal SVC or IVC is determined to be a CVAD, whether it is inserted centrally or peripherally (Bodenham & Hamilton, 2009).

The SVC is a large bore vessel approximately the width of a person's thumb (Dougherty, 2007). A large volume of venous blood drains from the cranium and upper peripheral vessels into the SVC headed for the right atrium and ultimately the lungs to be re-oxygenated. The walls of the SVC are thicker than in the peripheries and the flow is greater (2litres per minute in the SVC versus 10ml per minute in the digital or metacarpal veins) (Dougherty, 2007). This greater blood volume and flow in the SVC allows for medication to be mixed and diluted in the blood at a greater rate than in the peripheral vessels which reduces the risk of vessel inflammation, necrosis or infection (Bodenham & Hamilton, 2009; Dougherty, 2007).

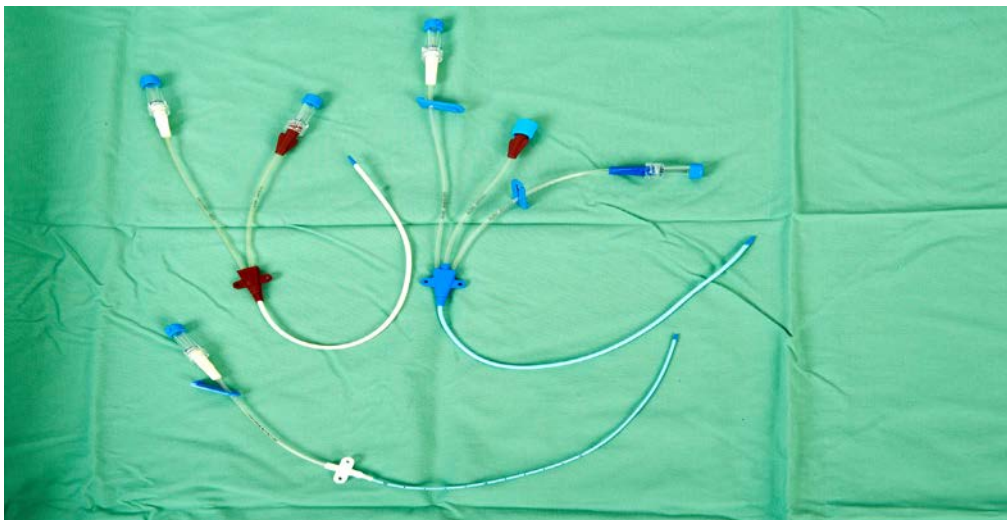
Central venous access devices also prevent more serious complications that can occur from peripheral administration of vesicant medications such as infiltration and extravasation. This can occur where medication leaks from the peripheral vessel into the surrounding tissue causing tissue inflammation, and potentially death of the surrounding tissue and nerves. This tissue damage may be so extensive it may ultimately require surgical intervention (Hankin & Louis, 1985; Phillips, Collins, & Dougherty, 2011; Sauerland et al., 2006).

Central venous access device placement was initially reported in 1952 by Aubaniac, who described his experience with catheterising the subclavian vein for the purpose of rapid fluid resuscitation in military casualties (Eerola, Kaukinen, & Kaukinen, 1985). Central venous access device placement has since developed and become the route of choice internationally for the administration of vesicant medication,

parenteral nutrition and remains the gold standard for patients who require long term vascular access (Bodenham & Hamilton, 2009).

A Central Venous Catheter (CVC) is one type of CVAD that is inserted percutaneously into the great veins of the neck (internal jugular vein), thorax (subclavian vein) or groin (femoral vein). There are many designs of CVCs that are currently in use internationally. These catheters are typically made of a soft polyurethane material and can consist of a single lumen or multiple lumens dependant on patient's treatment regime – see Figure (1) (Bodenham & Hamilton, 2009). (Image copyright approval given by Teleflex Corporation USA)

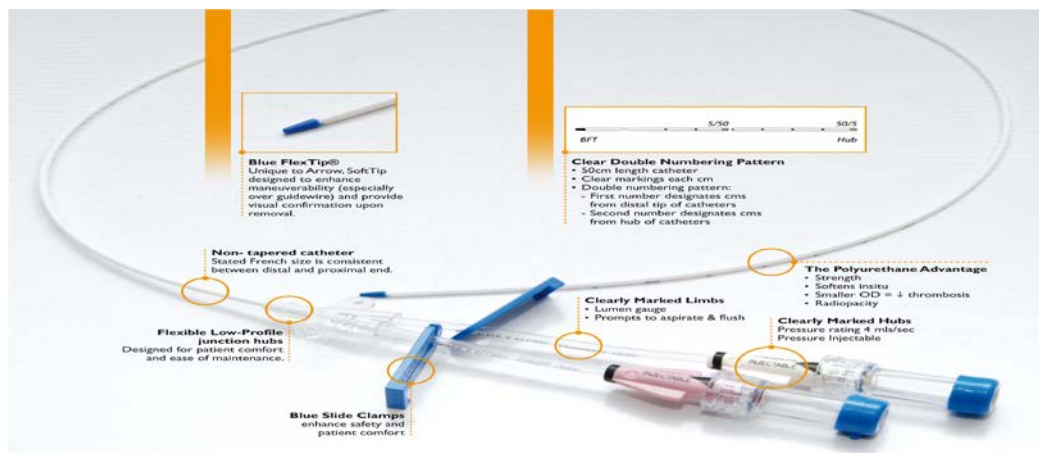
Figure 1: Image of single, double and triple lumen 20cm CVC.



A Peripherally Inserted central Catheter (PICC) is another type of CVAD. The distal tip of the catheter terminates in the central circulation; however the device is usually inserted via the upper peripheral veins (antecubital veins). A PICC is longer than a CVC (20cm vs. 40 - 60cm respectively) as it has further to travel along the venous route to the central circulation.

A PICC is either made of soft silicone material or polyurethane. A PICC can consist of a single to multiple lumens dependant on patient treatment – see Figure (2). Peripherally inserted central catheters are becoming increasingly popular as they are inserted into the upper peripheral veins as opposed to the larger central veins which reduces the risk associated with cannulating larger vessels within or adjacent to the thorax (Bodenham & Hamilton, 2009). (Image copyright approval given by Teleflex Corporation USA)

Figure 2: Double lumen PICC



Midline catheters are not CVADs as the catheter tip does not terminate in the distal SVC or IVC. The catheter is inserted peripherally, much like a PICC but is only 20cm in length and terminates at the axillary vein in the upper arm – see Figure (3). Although not a CVAD, midlines have a purpose for patients requiring intermediate length intravenous treatments of between 4-6 weeks where medication is not too vesicant to cause vessel irritation. Midlines have a lower risk of phlebitis compared to peripheral cannulas along with a lower rate of infection (Goetz, Miller, Wagener, & Muder, 1998; Gorski & Czaplewski, 2004). A midline catheter avoids the repeated trauma of regular peripheral cannula changes as only one device is used for the entirety of the treatment (Anderson, 2004, 2005).

Figure 3: Midline catheter instu. (Image copyright approval given by Teleflex Corporation USA).



Central venous access devices play a significant role in delivering parenteral treatment for many acute and chronic disorders. However, the use of such devices are associated with procedural complications that can pose a number of risks to the patient. Minor complications include pain and anxiety from multiple attempts at cannulation to more serious complications that may lead to life threatening situations. Some of the major procedural complications associated with CVAD insertion include:

- *Haemorrhage*, where a significant loss of blood has occurred from puncturing a vein or inadvertent arterial puncture. Patients may bleed either internally or externally. It is estimated that patients with coagulation disorders can (in rare cases) lose in excess of 40% of circulating volume. This large loss of blood would cause hypovolaemia and require blood transfusion (Mumtaz et al., 2000; Robinson, Robinson, Cohn, Garg, & Armstrong, 1995).

- *Pneumothorax*, where the lining of lung has been compromised and punctured with a needle. A pneumothorax can be asymptomatic and not be visible on a chest x-ray, or it can be life threatening where vital structures such as the heart are compressed leading to cardiac arrest and death (tension pneumothorax). A pneumothorax may require the insertion of an inter costal catheter attached to an underwater seal drain to re expand the lung (Bodenham & Hamilton, 2009; Robinson et al., 1995).
- *Cardiac dysrhythmias* occur when the metal spring guide wire that is used during CVC and or PICC insertion comes in contact with the interior walls of the heart or when a catheter is placed too deeply terminating in the right atrium. This can generate cellular excitability in the affected region leading an altered heart rhythm that may be self-limiting such as generated ectopic beats or more serious cardiac rhythms that require intervention (Arenas-Marquez et al., 2001; Johnson, Saltzman, Suh, Dahms, & Leonard, 1998; Kusminsky, 2007).
- Poor insertion technique or lack of adherence to strict aseptic technique when inserting or accessing CVADs can contribute to intravascular infection. Catheter related blood stream infection (CRBSI – see glossary page 18) or Central line associated bacteraemia (CLAB – see glossary page 18) occur when the CVAD becomes a portal of entry for pathogens to enter the blood stream (Hanna & Raad, 2005). Catheter related intravascular infections are deemed to be largely preventable as they are most likely due to poor clinician adherence to practice guidelines. Catheter related blood stream infections and CLABs are a serious cause of concern as they have been implicated in increasing the risk of mortality and have a marked associated treatment cost along with increased length of hospital stay (Berenholtz et al., 2004; Hanna & Raad, 2005).

The Contemporary Clinical Environment:

The successful insertion of CVCs and PICCs relies on clinician expertise which in turn is determined by training, credentialing and procedural volume. Historically, clinical expertise was seen to be synonymous with the medical profession where central venous access was the domain of the medical practitioner. Clinical practice however, is continuously evolving whereby the development of new diagnostic tools and new interventional techniques has spurred new clinical sub specialities. This changing environment is challenging traditional clinical work practice and competing with the work and teaching demands for senior clinicians (Dowling, Barrett, & West, 1995; S. Williams, Dale, Glucksman, & Wellesley, 1997).

Healthcare organisations have looked towards models of care that can meet these organisational challenges that involve inter professional collaboration where traditional role demarcation has been eroded with the overall aim to improve patient health outcomes and organisational efficiency. Increased clinical autonomy for nursing has been used as a strategy to relieve medical practitioners of some existing procedural work in order to further specialise and adopt new clinical techniques (Pearson & Peels, 2002; C. A. Williams & Valdivieso, 1994).

Dedicated service provision has also been developed as a model to improve both quality of care and patient safety. Dedicated services promote the development of intimate knowledge and specialisation further enhancing health outcomes. Dedicated services use an inter professional ethos where clinicians focus on patient outcomes with interdisciplinary clinical specialisation (Sudlow, Rodgers, Kenny, & Thomson, 1995; Weissman & Griffie, 1994). Advanced practice nurses are seen as integral in the development of such services because of the ability of nurses to provide the crucial link between the patient and the medical specialist. Follow up care and trouble shooting at a clinical level also facilitates better organisational efficiency with decreased complication or delays in treatment (Byers & Brunell, 1998; Cowan et al., 2006).

Nurse-led care is inspired through dedicated service provision which includes a holistic approach to patient care. Advanced practice nurses who work in collaboration with medical practitioners and other allied health care providers, can offer valuable contribution to the clinical care of acute and chronically ill patients. Nurse-led care is seen as a model that not only improves patient safety and outcomes but also as a platform for clinical training for junior medical and nursing clinicians (Byers & Brunell, 1998; Cowan et al., 2006; Cullum et al., 2005; Strömberg et al., 2003).

Nurse-led CVAD placement is increasingly seen as a model that can improve vascular access outcomes for a variety of patient cohorts. Nurse-led vascular access teams provide the knowledge required for undertaking patient assessment, inserting the right intravenous device and limiting the risk of vessel damage (Barton, Danek, Johns, & Coons, 1998). Nurse-led CVAD placement can also promote vessel health by the use of evidence based guidelines and consistently applying them to the patient plan of care (Hawes, 2007; Kokotis, 1999).

PROBLEM STATEMENT

Millions of CVADs are inserted in health care facilities across the world every year, exposing patients to iatrogenic complications. The insertion of CVADs by junior medical practitioners with minimal experience or supervision can pose unnecessary risk to patient safety. Procedural load plays a significant role in successful CVAD insertion (Taylor & Palagiri, 2007). Senior medical staff with competing specialty work demands who have sporadic procedural exposure with CVADs may not be the most appropriate clinicians to insert these devices (Hamilton, 2005).

Competing work demands for both junior and senior medical staff can impact greatly on the timely insertion of CVADs for patients. A delay in CVAD insertion due to

excessive medical workload is a significant problem that leads to a delay in treatment for many patients. This can also affect organisational efficiency where a delay in treatment can increase length of hospital stay and increase health care costs. Many health care settings ultimately want to reduce cost by improving treatment through early intervention and timely treatment with the aim to provide this care in a safe manner by competently trained clinicians to reduce the risk of adverse events. (Casey & Davies, 2012; Cowan et al., 2006; Waterhouse, 2002).

Nurse-led CVAD placement can provide a beneficial organisational solution to this problem; however, there is a paucity of scientific literature on how this model of care can improve patient safety, health outcomes and organisational efficiency. A small number of studies have been published discussing the merits of nurse-led CVAD insertion, however they are supported by limited observational data (Casey & Davies, 2012; Ean et al., 2006; Gopal, Fitzsimmons, & Lawrance, 2006; Hamilton, 2005).

This thesis addresses the paucity of research regarding the lack of outcome data supporting nurse-led CVAD insertion by undertaking a series of discrete studies that address the following aims:

- To identify the best available evidence on the genesis and implementation of nurse-led CVAD placement and its impact on patient care.
- To identify supporting evidence that specialisation in vascular access can influence patient outcomes through the selection of the most appropriate device for the patient's therapeutic needs.
- To establish nurse-led CVAD placement as a safe alternative to traditional service models that improve quality of care and patient safety and also improve organisational efficiency.

SIGNIFICANCE OF THIS THESIS

This work describes, for the first time in a structured scientific manner, the clinical outcomes of nurse-led CVAD insertion. The studies published through this programme of research were designed to provide evidence that nurse-led CVAD insertion and care provides quality patient outcomes. These findings could then be used to determine the value of non-medical CVAD placement.

METHODOLOGY

The research methods comprised in this thesis were exclusive to each discrete study. The outcomes of interest were analysed and interpreted for each published study.

- Study 1 (chapter 2): *A review of the nursing role in central venous cannulation: implications for practice, policy and research*. This study used an integrative literature review method to identify the best available evidence on nurses inserting CVCs. An integrative review method is particularly useful in health services research. This method of review differs from traditional systematic reviews and meta analyses as it allows for the inclusion of manuscripts that are both experimental and non-experimental in design (M. C. Smith & Stullenbarger, 1991; Whitemore & Knafel, 2005).

Following consultation with a health care librarian, the electronic databases CINAHL, Medline, Embase and the Internet were searched using key words including 'central venous catheter', 'catheterisation', 'nursing role', 'advanced practice nurses', 'clinical nurse specialists', 'nurse practitioner', 'clinical nurse consultant' and 'advanced practice roles'. The reference lists of published materials were searched for additional literature. Journals held locally were hand searched for relevant articles. The World Wide Web was searched using the Google Scholar and Yahoo search engines for related electronic documents. Studies were included for the review if they described

the role of nurses in the advanced practice role of CVC insertion in an adult population, using either tunnelled or non-tunnelled techniques. Articles relating to the nursing role in PICC insertion were excluded as many papers had previously been published on nurse led PICC insertion.

Retrieved manuscripts in this review reported complication rates as proportions that were then calculated at 95% confidence intervals to ascertain range for individual studies as point estimates which then gave an overall combined result for each complication that were generated onto forest plots.

- Study 2 (chapter 3): *Establishing a nurse-led central venous catheter insertion service*. This study aimed to document the development course of a nurse-led CVC insertion service. We reviewed archival information such as reports, electronic communications and minutes of departmental meetings which were then analysed using thematic content analysis (Marconi & Rudzinski, 1995; Reis & Judd, 2000; C. P. Smith, 1992) on the process of establishment of a nurse led central venous catheter insertion service. Semi-structured questionnaires were also undertaken with key individuals who were involved in establishing the service if they were still employed in the hospital. Administrative data from the central line service data base was tabulated and presented as frequencies and proportions.
- Study 3 (chapter 4): *The use of midline catheters in the adult acute care setting – clinical implications and recommendations for practice*. An integrative literature review method was used to identify the best available literature on the use of midline catheters in acute care settings. After consultation with a health care librarian with expertise in clinical literature

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 chosen because of the heterogeneity of the reviewed studies. This method allows for the inclusion of varying designs and it can provide a better understanding of the topic of interest (M. C. Smith & Stullenbarger, 1991; Whittmore & Knafl, 2005). Studies were included in this review if they described the use of midline catheters 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 midline catheters. The search was limited to the English language and in adult acute care populations. All articles meeting the search criteria were reviewed by the primary author and two co-authors using a previously validated critical appraisal tool (Goldsmith, Bankhead, & Austoker, 2007).

- Study 4 (chapter 5): *Central venous catheter insertion by a clinical nurse consultant or anaesthetic medical staff: a single-centre observational study.* A prospective audit of consecutive CVC insertions by a clinical nurse consultant and anaesthetic medical staff was undertaken to review the number of CVCs inserted; differences between outcomes in the two groups and complications during and after insertion. Descriptive statistics were presented as frequencies and proportions. Differences in outcomes between the two groups were assessed using the Student *t*-test for analysis of continuous data and the Fisher's exact test for categorical data. The comparative incidence of CRBSI was calculated using a χ^2 distribution and presented as per 1,000 catheters (we were unable to capture all catheters removed so rates were presented as per 1,000 catheters rather than catheter days).
- Study 5 (chapter 6): *Nurse-led central venous catheter insertion –procedural characteristics and outcomes of three intensive care based catheter placement services.* The NSW Central Line Associated Bacteraemia Intensive

Care Units (CLAB-ICU) project was a successful ‘top down, bottom up’ initiative aimed at reducing the incidence of CLAB in NSW (Burrell et al., 2011). All adult intensive care units (ICUs) in NSW and paediatric ICUs participated between March 2007 and June 2009. The project was coordinated by the NSW Clinical Excellence Commission (CEC). The project promoted standard aseptic insertion technique to minimise the risk of CLABs (Burrell et al., 2011) .

Three nurse-led CVAD placement services, based in three separate ICUs contributed to the CLAB-ICU project. De-identified data were retrieved from the original CLAB-ICU data set pertaining to the nurse-led CVAD insertion services from the CEC. Categorical data which included catheter type, catheter coating and insertion outcome were tabulated and differences analysed using the Pearson’s chi square statistic and the Fisher’s exact test. Confidence intervals were used to assess range with some variables and then to assess differences across the three nurse-led CVAD insertion groups.

- Study 6 (chapter 7): *Central venous catheter placement by advanced practice nurses demonstrates low procedural complication and infection rates – A report from 13 years of service.* This study was undertaken in a large university affiliated, 850 bed hospital situated in South Western Sydney, Australia. A central venous catheter placement service operating within the ICU provides an elective catheter placement service for patients throughout the hospital. Outcomes associated with CVCs placed in adult patients between November 1996 and December 2009 was presented. Report cases were categorised in accordance with the four divisional streams of the hospital - Medical; Surgical; Critical Care; as well as Women and Child Health.

The outcomes of interest were (1) patient and device characteristics, (2) procedural complications (3) incidence of catheter related blood stream infection. The authors used the Centres for Disease Control and Prevention

(CDC) definitions for laboratory-confirmed CRBSI (Horan, Andrus, & Dudeck, 2008; O'Grady et al., 2011). Incidence rates of procedural outcomes and catheter selection were presented as frequencies and proportions. Non parametric tests (χ^2 test and Fishers' exact test) were used to assess associations between some categorical variables. The incidence rates of CRBSI per 1000 catheter days were calculated for each clinical division after clinical record review for derivation of the denominator.

OVERVIEW OF THE THESIS

This thesis is presented in eight chapters. Six of these chapters are presented in the form of published peer reviewed journal articles. Chapter one outlines the background and purpose of this thesis, along with providing the rationale and methods for each study incorporated in the thesis. An overview of the thesis and glossary of terms are also incorporated in this chapter. Chapter two presents an article published in the *Journal of Clinical Nursing*. This paper is an integrative literature review on the role of nurses inserting central venous catheters and discusses the implications for health policy, clinical practice and research.

Chapter three presents a paper published in the *Journal of the Association for Vascular Access*. It gives a historical account of the establishment of a nurse led central venous catheter placement service and discusses the major barriers and facilitators encountered when the service was initially developed. Chapter four presents a published paper in the *Journal of the Association for Vascular Access*. This study was an integrative literature review on the role of midline catheters in the acute care setting as an alternative the CVCs and PICCs. The study developed and made recommendations for the use of these VADs.

Chapter five presents a published paper in *The Journal of Critical Care and Resuscitation*. This was an observational study comparing the procedural and infection outcomes between a clinical nurse consultant and anaesthetic medical staff. The comparative outcomes served as further evidence that nurse led CVC insertion can be safe and promote good catheter outcomes. Chapter six presents a published paper in *The International Journal of Nursing Studies*. This manuscript was a study reviewing the procedural outcomes and infection rates of three nurse led CVC insertion services based in three separate ICUs in NSW. The summary of the major findings from this study provided further evidence for the validity of this model of CVC insertion. The results were favourable for the nurse-led model, with minimal insertion complications or infections.

Chapter seven presents a paper in journal *Critical Care Medicine*. This publication was a report on 13 years of procedural and infection data from this dedicated CVC insertion service operated by specialist nursing staff. The report found the outcomes from a dedicated service with significant procedural volume were favourable and exceeded published outcome data from other institutions.

Chapter eight presents a summary of the major findings from these studies and makes recommendations relevant to health services and for increasing scope of practice of nurses in vascular access.

GLOSSARY OF TERMS

The following terms were used in this thesis and defined as:

Advanced Practice Nurse: A registered nurse who has acquired the expert knowledge, complex decision-making skills and clinical competencies for expanded clinical practice.

Cardiac Dysrhythmias: A rate or rhythm of the heart that is beating too fast, too slow, or with an irregular rhythm.

Central line associated bacteraemia (CLAB): A laboratory confirmed bloodstream infection where the catheter was in place for greater than 2 days on the date of positive blood culture not attributed to an infection from another body site (no sample of catheter segment is required).

Catheter Related Blood Stream Infection (CRBSI): Bacteria colonising the surface of the catheter are released into the blood stream causing a blood stream infection (bacteraemia). A diagnosed CRBSI occurs when a sample of the catheter and blood from the patient are sent for pathogen testing when no other sources of infection are suspected. The results are returned with the same pathogen in the blood as the catheter material.

Central Venous Access Device (CVAD): An acronym used to describe a catheter that terminates in the superior vena cava. Typically central venous catheters and peripherally inserted central catheters are termed CVADs.

Central Venous Catheter: An intravascular device that is inserted via the central veins where the catheter tip terminates in the distal superior vena cava. The catheter is usually comprised of a silicone or polyurethane material. The catheter may have a single or multiple lumens.

Clinical Nurse Consultant (CNC): A registered nurse who provides advanced care and consults on clinical issues related to their specialty. A CNC usually has a broad scope of practice and is involved in inter disciplinary care (works with a broad range of health disciplines) of patients.

Clinical Nurse Specialist (CNS): A registered nurse who provides care to patients at an advanced level in a holistic manner whose knowledge and clinical skill are beyond the scope of a generalist nurse.

Haemorrhage: Profuse internal or external bleeding from the blood vessels. The most obvious cause of hemorrhage is trauma or injury to a blood vessel such as the puncture from a large gauge needle.

Midline Catheter: An intravascular device that is inserted via the upper peripheral vessels where the catheter tip terminates at the axillary vein. The catheter is usually comprised of a silicone or polyurethane material. The catheter may have a single or multiple lumens.

Operator: A clinician who is tasked with inserting a central venous catheter.

Peripherally Inserted Central Catheter: An intravascular device that is inserted via the upper peripheral vessels where the catheter tip terminates in the distal superior vena cava. The catheter is usually comprised of a silicone or polyurethane material. The catheter may have a single or multiple lumens.

Pneumothorax: An abnormal collection of air or gas in the pleural space that separates the lung from the chest wall and which may interfere with normal breathing.

Vascular Access Device (VAD): This is a term used for any catheter or cannula device situated in a blood vessel. Typically peripheral cannulas are termed VADs.

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CHAPTER TWO

Publication Title: A review of the nursing role in central venous cannulation: implications for practice policy and research

This chapter reports an integrative literature review that described the state of the science of nurse led central venous catheter insertion. This chapter introduces the article presented as an original reprint published in the *Journal of Clinical Nursing* (2010) Volume 19, Issue 11-12, Pages 1485 – 1494. (Impact factor 1.233)

Background

Increasing medical specialisation and demands for specialist skills has necessitated interprofessional collaboration between doctors and nurses in many hospital settings and outpatient areas in order to maintain adequate and safe patient care. There has been a growing trend in hospital settings internationally where specialist nurses are undertaking clinical duties previously done by junior doctors (Dowling, Barrett, & West, 1995). Collaboration between specialist nurses and medical practitioners has shown to be beneficial with improved patient care, reduced length of hospital stay and with no effect on mortality or readmission rates (Cowan et al., 2006).

Outcomes measures and descriptions of advanced practice nurses have been undertaken in both the United Kingdom and North America since the 1970's. Most studies have shown equivalence in patient outcomes between medical practitioners and specialist nurses (Dunn, 2008; Mundinger, 1994).

The use of CVCs have increased significantly in the past two decades in both the in hospital and outpatient setting with these devices being an integral component for many therapies. Traditionally, the insertion of such devices has been the role of the medical practitioner as they were deemed to have significant adverse incidents if insertion was suboptimal which could lead to serious clinical deterioration (Arenas-Marquez, Anaya-Prado, Barrera-Zepeda, & Gonzalez-Ojeda, 2001). The procedural outcomes of nurses inserting central venous catheters had not been formally reviewed prior to this study and were a significant first step in validating such an important clinical role.

Aim of the study:

The study aimed to synthesise existing information on procedural outcomes of nurses inserting central venous catheters. An integrative literature review was chosen as the review method of choice because of the heterogeneity in study design which precluded the ability to undertake a meta-analysis (Goldsmith, Bankhead, & Austoker, 2007; Whitemore & Knafl, 2005).

Brief results of the study:

Ten studies in total were reviewed. The majority of studies were non experimental in design. Recurring themes were noted that included medical staff shortages and delay in catheter placement provided the catalyst for this emerging advanced practice role. Concern for patient safety and junior medical staff placement were also noted as significant themes. The studies did not demonstrate differences in rates of adverse events between specialty nurses and were similar to the wider and largely published

medical literature. Due to the small number of studies and lack of experimental studies, no formal conclusions were deduced.

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Erratum: There is an error on page 1487 of the publication. At the end of paragraph one, "(Table 1)" has been inserted. This was a typographical error.

REVIEW

A review of the nursing role in central venous cannulation: implications for practice policy and research

Evan Alexandrou, Timothy R Spencer, Steve A Frost, Michael JA Parr, Patricia M Davidson and Kenneth M Hillman

Aims and objectives. The aim of this article is to review published studies about central vein cannulation to identify implications for policy, practice and research in an advanced practice nursing role.

Design. Modified integrative literature review.

Methods. Searches of the electronic databases: Cumulative Index of Nursing and Allied Health Literature (CINAHL); Medline, Embase, and the World Wide Web were undertaken using MeSH key words. Hand searching for relevant articles was also undertaken. All studies relating to the nurses role inserting central venous cannulae in adult populations met the search criteria and were reviewed by three authors using a critical appraisal tool.

Results. Ten studies met the inclusion criteria for the review, all reported data were from the UK. There were disparate models of service delivery and study populations and the studies were predominantly non experimental in design. The results of this review need to be considered within the methodological caveats associated with this approach. The studies identified did not demonstrate differences in rates of adverse events between a specialist nurse and a medical officer.

Conclusions. There were only a small number of studies found in the literature review and the limited availability of clinical outcome data precluded formal analysis from being generated.

Relevance to clinical practice. Central vein cannulation is potentially an emerging practice area with important considerations for policy practice and research. Training specialist nurses to provide such a service may facilitate standardising of practice and improving surveillance of lines, and possibly improve the training and accreditation process for CVC insertions for junior medical officers. For this to occur, there is a need to undertake well-conducted clinical studies to clearly document the value and efficacy of this advanced practice nursing role.

Key words: central venous cannulae, critical care, Health Services Research, multiprofessional care, nurses, nursing

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Introduction

Central venous access in contemporary clinical practice

Central venous cannulae (CVCs) are used for delivering vesicant medications, long term intravenous therapy, paren-

teral nutrition, and in some instances for individuals with poor peripheral venous access. The CVC is also used in critical care settings for haemodynamic monitoring (Taylor & Palagiri 2007). While traditionally confined within specialised areas such as intensive care units and operating theatres, central venous cannulation is being adopted across

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many specialist in-patient settings, and more recently in community practice (Hamilton 2005). The nursing role in inserting CVCs is being developed in response to local organisational factors, such as medical workforce shortages and increasing demand coinciding with the development of the advanced practice nursing role (Dowling *et al.* 1995).

Complications from CVC insertion include arterial puncture, pneumothorax, haematoma, cardiac arrhythmias and venous perforation and are associated with mortality rates as high as 47% (Comfere & Brown 2007). These procedural risks possibly explain why traditionally CVC insertions have been performed by medical officers (Table 1).

Due to the potential for iatrogenic events associated with CVC insertion, the procedure requires trained clinicians that can assess a patient's vascular access and determine the most appropriate insertion site, accommodating a variety of clinical conditions as well as consideration of patient comfort. The type and duration of therapy, will determine the choice of catheter material, the number of lumens, and the tunnelling requirement (Hamilton 2004a). In some instances the use of ultrasound guidance, particularly in the obese or coagulopathic patient can minimise procedural complications (Bishop *et al.* 2007).

Advanced practice nursing roles

In health care settings the boundaries between medical and nursing clinicians in respect to their clinical work and accountabilities is constantly being challenged due to advancing technologies and increased specialisation that is also changing the mode of health care delivery (Dowling *et al.* 1995). Since the advanced clinical nurse career path was first described in the 1980's, there has been much written in the literature in regard to the role of specialist nurses (Wright 1997, Pearson & Peels 2002a). In addition to formalising the advanced practice nursing role, the clinical nurse specialist has also evolved in response to workforce and practice changes in health care delivery as well as providing support for the workload of junior medical officers (Pearson & Peels 2002b). The advanced practice nursing role is defined by the International Council of Nursing as a registered nurse who

has acquired the expert knowledge base, complex decision-making skills and clinical competencies for expanded practice (Schober & Affara 2006). Specialist nurses across a range of practice settings are a critical link in providing continuity and coordination of care. There is increasing high quality evidence that specialist nurses can provide efficient, cost effective care that directly influences patient outcomes (Wright 1997). Additionally, as a greater emphasis is placed upon cost effectiveness and quality of care, nurse specialists will be integral in the development and shaping of future health policy, particularly within the realm of health outcomes and health outcomes research (Chornick 2008).

The nursing role in the insertion and management of central venous catheters

Dedicated vascular access teams have, historically, been limited to peripheral cannulation with some teams having the ability to insert peripherally inserted central catheters (PICCs). Dedicated vascular access teams have demonstrated improvement in patient safety, better catheter outcomes and a reduction in catheter related nosocomial infections (Sharpe 2006). Nurse-led vascular access teams have also demonstrated improvements in hospital efficiency (Hunter 2003).

Successful insertion rates for PICCs by nurses have been reported to be >93% (Funk *et al.* 2001, Burns 2005, Gamulka *et al.* 2005). Nurse-led teams also provide important follow up for consultancy and education which traditionally are not available with medical services due to competing demands. This consultancy and education role can include clinician and patient education, line follow up and management of complications (Fong *et al.* 2001, Ean *et al.* 2006).

Although the risks associated with CVC insertion are well documented, the nursing role in relation to insertion and line management is not as well described in published literature, nor is the role delineation with medical colleagues well defined. This integrative literature review seeks to describe the state of the science in relation to the advanced practice nursing role in the insertion and management of CVCs in order to inform policy, practice, education and research strategies.

Methods

The integrative review is a method that allows for the inclusion of varying designs, in order to provide a comprehensive review of the research of interest (Whittemore & Knafelz 2005). An integrative review is of particular benefit in scoping of a problem or issue and empirically documenting a

Table 1 Complication rates from cvc insertion

Complication	I. Jugular (%)	S/Clavian (%)	Femoral (%)
Arterial puncture	6.3–9.4	3.1–4.9	9.0–15
Haematoma	0–9.4	1.2–2.1	3.8–4.4
Pneumothorax	0–0.7	1.2–3.1	NA
Venous perforation	0.2	1.2	0
Total	6.3–12.1	6.2–10.7	12.8–19.4

Source: (Comfere & Brown 2007)

plan of action and/or considering implications for policy, practice and research. We extended this predominately narrative method of analysis by generating forest plots for complication rates (Lewis & Clarke 2001). A forest plot is a graphical display that shows the strength of the evidence. Although initially developed for formal meta analysis, this method is also used in observational studies (Lewis & Clarke 2001). We did not undertake a formal meta-analysis as the complication rates were reported as crude rates and there was heterogeneity of study methods. Following consultation with a health care librarian, the electronic databases CINAHL, Medline, Embase and the Internet were searched using key words including 'central venous catheter', 'catheterisation', 'nursing role', 'advanced practice nurses', 'clinical nurse specialists', 'nurse practitioner', 'clinical nurse consultant' and 'advanced practice roles'. The reference lists of published materials were searched for additional literature. Journals held locally were hand searched for relevant articles. The World Wide Web was searched using the Google Scholar and Yahoo search engines for related electronic documents (Table 1).

Studies were included for the review if they described the role of nurses in the advanced practice role of CVC insertion in an adult population, using either tunnelled or non tunnelled techniques. Articles relating to the nursing role in PICC insertion were excluded. In light of the small number of studies, all published manuscripts whether using experimental or non-experimental methods were included in the review. The literature review strategy was supervised by a health librarian with expertise in undertaking integrative and systematic literature reviews. All articles meeting the search criteria were reviewed by the primary author and two co-authors using a critical appraisal tool.

The complications reported in the retrieved manuscripts were pneumothoraces, sepsis, arterial puncture and misplaced tip. Percentages from the papers were tabulated and then calculated at 95% confidence intervals. Forest plots were generated (using random effects) to exemplify the results of individual studies as point estimates to give an overall estimate with the combined results. The forest plot was used for the results of the four complications to facilitate comparison of events using STATA Version 7 (STATA Corporation, College Station, TX, USA).

Findings

A total of 525 papers were identified using the search strategy described. Abstracts of these papers were reviewed by the primary author (EA) to assess whether the papers met the inclusion criteria. This process identified ten papers that met

the inclusion criteria. These papers were then reviewed by co-authors to confirm that they met the inclusion criteria. Data were then extracted from the papers by three reviewers and are summarised in Table 2. Following a narrative analysis, three themes emerged from this review relating to: (i) development of a nurse-led service; (ii) Outcomes of nurses inserting central lines; and (iii) Educational requirements for nurse credentialing. These are discussed below:

Development of a nurse led service

The majority of articles (seven in total) were a retrospective report of the development of the nursing CVC insertion roles within each author's respective facilities. All ten articles, some including common authors, described care models in the UK.

Of interest, two articles discussed that one of the major determinants for service development was the delay in central line insertion. Delay times were reported from Waterhouse (2002) for a permanent dialysis catheter to be up to 48 days. This was reduced to a waiting period of between 2–5 days with the implementation of the nurse led service. Fitzsimmons *et al.* (1997) also showed that with the implementation of a nurse led service there was an increase from 80% of patients to 97% of patients acquiring their CVC on the same day.

Hamilton (2005) discussed issues associated with junior surgeon based line placement and why a nurse led service was developed in her facility. Issues included insertion risk, unacceptable rates of infection, misplaced lines, increased costs associated with repeat attempts by other clinicians and increased stress to the patient along with increased length of stay.

Kelly (2003) derived a multidisciplinary approach to developing a nurse led CVC service. This included the disciplines of microbiology, radiology, pharmacy, auditing department and bio engineering in assisting in the initial set up.

These reports illustrate that the nurse-led services have emerged based on a pressure to increase organisational efficiencies and improve patient outcomes. Such was the case also with Benton and Marsden (2002) where the medical CVC insertion service through the interventional radiology department grew rapidly and placed limitations on the service availability.

Outcomes of nurses inserting central lines

Complication rates were discussed and presented as crude rates in six of the ten articles. No weighting or statistical

Table 2 Reviewed papers

Study type	Participants	Interventions	Outcome																					
Author(s): Kelly (2003) Review article	Oncology patients requiring tunnelled CVC insertions for therapy 160 catheters placed by nurses Country: UK	Implementation of a tunnelled CVC service to reduce insertion waiting times Development of training and credentialing course for clinical nurse specialists to insert central venous catheters	From an audit of 20 patients the average waiting time was three days and no complications in 89% of catheter placements Changes in practice for the insertion of catheters included the use of chlorhexidine antiseptis, rationing catheter lumens (using single lumens where possible) and antibiotics not routinely given																					
Author(s): Hamilton <i>et al.</i> (1995) Review article	Surgical patients requiring tunnelled CVC insertions for TPN Medical patients requiring tunnelled CVC insertions for oncology therapy 559 Patients Country: UK	Implementation of a tunnelled CVC service to reduce insertion waiting times and improve patient outcomes Development of training and credentialing course for clinical nurse specialists to insert central venous catheters	<table border="1"> <thead> <tr> <th>Complication</th> <th>Number (n)</th> <th>Percent (%)</th> </tr> </thead> <tbody> <tr> <td>Pneumothorax</td> <td>6</td> <td>1</td> </tr> <tr> <td>Sepsis</td> <td>6</td> <td>1</td> </tr> <tr> <td>Nil</td> <td>548</td> <td>98</td> </tr> <tr> <td>Total</td> <td>560</td> <td>100</td> </tr> </tbody> </table> Training given to medical and nursing staff in management of CVCs	Complication	Number (n)	Percent (%)	Pneumothorax	6	1	Sepsis	6	1	Nil	548	98	Total	560	100						
Complication	Number (n)	Percent (%)																						
Pneumothorax	6	1																						
Sepsis	6	1																						
Nil	548	98																						
Total	560	100																						
Author(s): Casey and Davies (2003) Case/control study	Renal dialysis patients requiring CVC insertions for dialysis therapy 289 Patients Country: UK	Comparative analysis between advanced practice nurses and medical officers on the insertion of dialysis CVCs Patients were studied over a 24 month period, the outcomes examined included type of CVC used, insertion site, line survival rates and reason for removal	Analysis between advanced practice nurses and medical officers <table border="1"> <thead> <tr> <th>Category</th> <th>p-value</th> </tr> </thead> <tbody> <tr> <td>Age</td> <td>0.517</td> </tr> <tr> <td>Sex</td> <td>0.783</td> </tr> <tr> <td>Perm vs. temp CVC</td> <td>0.387</td> </tr> <tr> <td>Elective removal</td> <td>0.323</td> </tr> <tr> <td>Non elective removal</td> <td>0.938</td> </tr> <tr> <td>Removal for infection</td> <td>0.1437</td> </tr> </tbody> </table> No statistical difference found between the two groups	Category	p-value	Age	0.517	Sex	0.783	Perm vs. temp CVC	0.387	Elective removal	0.323	Non elective removal	0.938	Removal for infection	0.1437							
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Removal for infection	0.1437																							
Author(s): Gopal <i>et al.</i> (2006) Descriptive article	Patients requiring subclavian CVC insertion for TPN and oncology therapy 348 Patients Country: UK	Prospective study over a 6 month period where information was recorded that included: Indication, diagnosis, type and position of catheter, complications during procedure and patient satisfaction	<table border="1"> <thead> <tr> <th>Complication</th> <th>Number (n)</th> <th>Percent (%)</th> </tr> </thead> <tbody> <tr> <td>Pneumothorax</td> <td>3</td> <td>1</td> </tr> <tr> <td>Arterial puncture</td> <td>16</td> <td>4</td> </tr> <tr> <td>Misplaced tip</td> <td>29</td> <td>8</td> </tr> <tr> <td>Failed procedure</td> <td>3</td> <td>1</td> </tr> <tr> <td>Nil</td> <td>294</td> <td>86</td> </tr> <tr> <td>Total</td> <td>345</td> <td>100</td> </tr> </tbody> </table> 98% of CVCs were inserted at the bedside and 76% of CVCs used were single lumen	Complication	Number (n)	Percent (%)	Pneumothorax	3	1	Arterial puncture	16	4	Misplaced tip	29	8	Failed procedure	3	1	Nil	294	86	Total	345	100
Complication	Number (n)	Percent (%)																						
Pneumothorax	3	1																						
Arterial puncture	16	4																						
Misplaced tip	29	8																						
Failed procedure	3	1																						
Nil	294	86																						
Total	345	100																						

Table 2 (Continued)

Study type	Participants	Interventions	Outcome																											
Author(s): Waterhouse (2002) Review article	Renal dialysis patients requiring CVC insertions for dialysis therapy 103 Patients Country: UK	Non analytic comparison of between advanced nurse practitioner's and medical officers on the insertion of dialysis CVCs Tertiary qualification and clinical training given to experienced renal nurse for the development of a service to insert renal dialysis catheters	<table border="1"> <thead> <tr> <th>Complication</th> <th>Number (n)</th> <th>Percent (%)</th> </tr> </thead> <tbody> <tr> <td>Pneumothorax</td> <td>1</td> <td>1</td> </tr> <tr> <td>Primary failure</td> <td>1</td> <td>1</td> </tr> <tr> <td>Infection in 72 hours</td> <td>1</td> <td>1</td> </tr> <tr> <td>Nil</td> <td>67</td> <td>98</td> </tr> <tr> <td>Total</td> <td>70</td> <td>100</td> </tr> </tbody> </table> <p>Significant difference in average waiting times between medical officers and nurses (48 days vs. 7 days). Minimal difference in complication rates between the two groups</p>	Complication	Number (n)	Percent (%)	Pneumothorax	1	1	Primary failure	1	1	Infection in 72 hours	1	1	Nil	67	98	Total	70	100									
Complication	Number (n)	Percent (%)																												
Pneumothorax	1	1																												
Primary failure	1	1																												
Infection in 72 hours	1	1																												
Nil	67	98																												
Total	70	100																												
Author(s): Benton and Marsden (2002) Descriptive article	Cancer patients requiring CVC insertion for oncology therapy No of Hickman lines: 45 Country: UK	Development of a training program and the appointment of a two nurses to safely place tunnelled CVCs Operating protocols were written and received trust board approval Training for the nurses included theory and practice. The practical component involved phantom techniques (turkey breasts) using ultrasound guidance	<p>45 Hickman lines had been placed at time of publication by nurses under ultrasound guidance</p> <p>The development of an <i>in vitro</i> model for clinical practice will aid other nurses and junior doctors the opportunity to gain experience in the insertion of tunnelled CVCs</p>																											
Author(s): Boland <i>et al.</i> (2005) Randomised controlled trial	Cancer patients requiring Hickman line insertion for therapy that were over 18 years of age 158 Blind insertions 197 Image guided insertions Country: UK	Two interventions were investigated: (i) blind insertion of a Hickman line and (ii) image guided insertion of a Hickman line Both interventions involved the use of the landmark technique for access to the subclavian vein The image guided arm involved the use of fluoroscopy for catheter placement	<table border="1"> <thead> <tr> <th>Complication</th> <th>Blind (%)</th> <th>Image guided (%)</th> </tr> </thead> <tbody> <tr> <td>Pneumothorax</td> <td>7 (3)</td> <td>2 (1)</td> </tr> <tr> <td>Line infection</td> <td>10 (4)</td> <td>14 (16)</td> </tr> <tr> <td>Tunnel infection</td> <td>11 (5)</td> <td>4 (2)</td> </tr> <tr> <td>Arterial puncture</td> <td>15 (16)</td> <td>13 (5)</td> </tr> <tr> <td>Misplaced tip</td> <td>32 (14)</td> <td>1 (1)</td> </tr> <tr> <td>Haematoma</td> <td>2 (1)</td> <td>4 (2)</td> </tr> <tr> <td>Nil</td> <td>158 (67)</td> <td>197 (83)</td> </tr> <tr> <td>Total</td> <td>235</td> <td>235</td> </tr> </tbody> </table> <p>At low costs, the image guided approach was favourable. Evidence showed that nurses can be trained to competently insert Hickman lines within a three month period</p>	Complication	Blind (%)	Image guided (%)	Pneumothorax	7 (3)	2 (1)	Line infection	10 (4)	14 (16)	Tunnel infection	11 (5)	4 (2)	Arterial puncture	15 (16)	13 (5)	Misplaced tip	32 (14)	1 (1)	Haematoma	2 (1)	4 (2)	Nil	158 (67)	197 (83)	Total	235	235
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Arterial puncture	15 (16)	13 (5)																												
Misplaced tip	32 (14)	1 (1)																												
Haematoma	2 (1)	4 (2)																												
Nil	158 (67)	197 (83)																												
Total	235	235																												

Table 2 (Continued)

Study type	Participants	Interventions	Outcome																		
Author(s): Fitzsimmons <i>et al.</i> (1997) Descriptive article	Cancer patients requiring CVC insertion for oncology therapy 200 CVC's inserted Country: UK	Development of a training program and the appointment of a clinical nurse specialist to insert CVC. Training was provided by experienced medical officers including tutorials Data was collected prospectively over a 12 month period. Standard operating procedures were developed	Between January 1996 and January 1995 the clinical nurse specialist inserted 200 CVCs with a 97% success rate The 3% failure rate was associated with obesity and upper mediastinal disease Overall there was a 1% pneumothorax rate																		
Author(s): Hamilton (2004b) Descriptive article	Medical/surgical patients requiring tunnelled CVC insertion for therapy 390 patient complications Country: UK	Development of a learning contract for a nurse specialist to insert CVCs. Training was provided by a consultant anaesthetist who was appointed as a tutor Ten components were developed for the learning contract Data on complications were collected prospectively over a three month period	<table border="1"> <thead> <tr> <th>Complication</th> <th>Number (n)</th> <th>Percent (%)</th> </tr> </thead> <tbody> <tr> <td>Pneumothorax</td> <td>3</td> <td>0.8</td> </tr> <tr> <td>Malposition</td> <td>35</td> <td>9.0</td> </tr> <tr> <td>Systemic infection</td> <td>4</td> <td>1</td> </tr> <tr> <td>Other</td> <td>348</td> <td>89</td> </tr> <tr> <td>Total</td> <td>390</td> <td>100</td> </tr> </tbody> </table> <p>Nurse led team remove all CVCs Increasing demand has increased number of specialist nurses being trained to insert CVCs</p>	Complication	Number (n)	Percent (%)	Pneumothorax	3	0.8	Malposition	35	9.0	Systemic infection	4	1	Other	348	89	Total	390	100
Complication	Number (n)	Percent (%)																			
Pneumothorax	3	0.8																			
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Author(s): Hamilton (2005) Descriptive article	Medical/surgical patients requiring tunnelled CVC insertion for therapy 212 patient complications Country: UK	Development of a learning contract for a nurse specialist to insert CVCs Training was provided by a consultant anaesthetist who was appointed as a tutor	<table border="1"> <thead> <tr> <th>Complication</th> <th>Number (n)</th> <th>Percent (%)</th> </tr> </thead> <tbody> <tr> <td>Pneumothorax</td> <td>2</td> <td>4</td> </tr> <tr> <td>Infection</td> <td>1</td> <td>1</td> </tr> <tr> <td>Nil</td> <td>209</td> <td>95</td> </tr> <tr> <td>Total</td> <td>212</td> <td>100</td> </tr> </tbody> </table> <p>Expansion of the service to incorporate community focused antibiotic service</p>	Complication	Number (n)	Percent (%)	Pneumothorax	2	4	Infection	1	1	Nil	209	95	Total	212	100			
Complication	Number (n)	Percent (%)																			
Pneumothorax	2	4																			
Infection	1	1																			
Nil	209	95																			
Total	212	100																			

testing was undertaken in four of these, rather percentages were presented as findings.

A prospective randomised control trial was undertaken by Boland *et al.* (2005) to examine the clinical and cost effectiveness between blind Hickman Line insertions and Hickman Line insertions inserted under image guidance. The study concluded that specialist nurses inserting Hickman lines were safe and effective when appropriate training was given.

Boland *et al.* (2005) was the only study that prospectively identified inclusion and exclusion criteria and defined complications rates. Five studies documented rates of pneumothorax (Fitzsimmons *et al.* 1997, Waterhouse 2002, Boland *et al.* 2005, Hamilton 2005, Gopal *et al.* 2006). The crude rate of pneumothorax was reported as between 1–4%. Confidence intervals were calculated and varied between studies as population samples were varied in size. However the average rate when computed was between 0.5–2.5% as seen on the forest plot.

Three authors discussed arterial puncture and misplaced tip as documented complications (Fitzsimmons *et al.* 1997, Boland *et al.* 2005, Gopal *et al.* 2006), the crude rates for arterial puncture ranged between 3–16%. The average calculated rates were between 2–6% (95%CI). The crude percentage for misplaced tip ranged between 0–14% and

once analysed using confidence intervals ranged between 0–9% (Fig. 1).

Casey and Davies (2003) undertook a small case control study, using non parametric two group comparative testing, between specialist nurses and medical officers. Outcome measures included: types of lines inserted; site selection for insertion; longevity of line and reason for removal. This study concluded that no significant difference was noted between the two groups examined in relation to baseline characteristics, insertion sites and catheter days.

Educational requirements for nurse credentialing

A key theme emerging from the retrieved articles was the discussion around the credentialing process for nurses to be accredited to insert CVCs. The article by Waterhouse (2002) discussed how a relevant master's degree course was developed by the affiliated hospital university. This course combined clinical and course work over a period of two years. The course work emphasised the medical and legal issues that accompany such an advanced practice role and in particular the issue of professional accountability.

Hamilton (2004b, 2005), Hamilton *et al.* (1995) discussed in two of her articles the learning contract that was

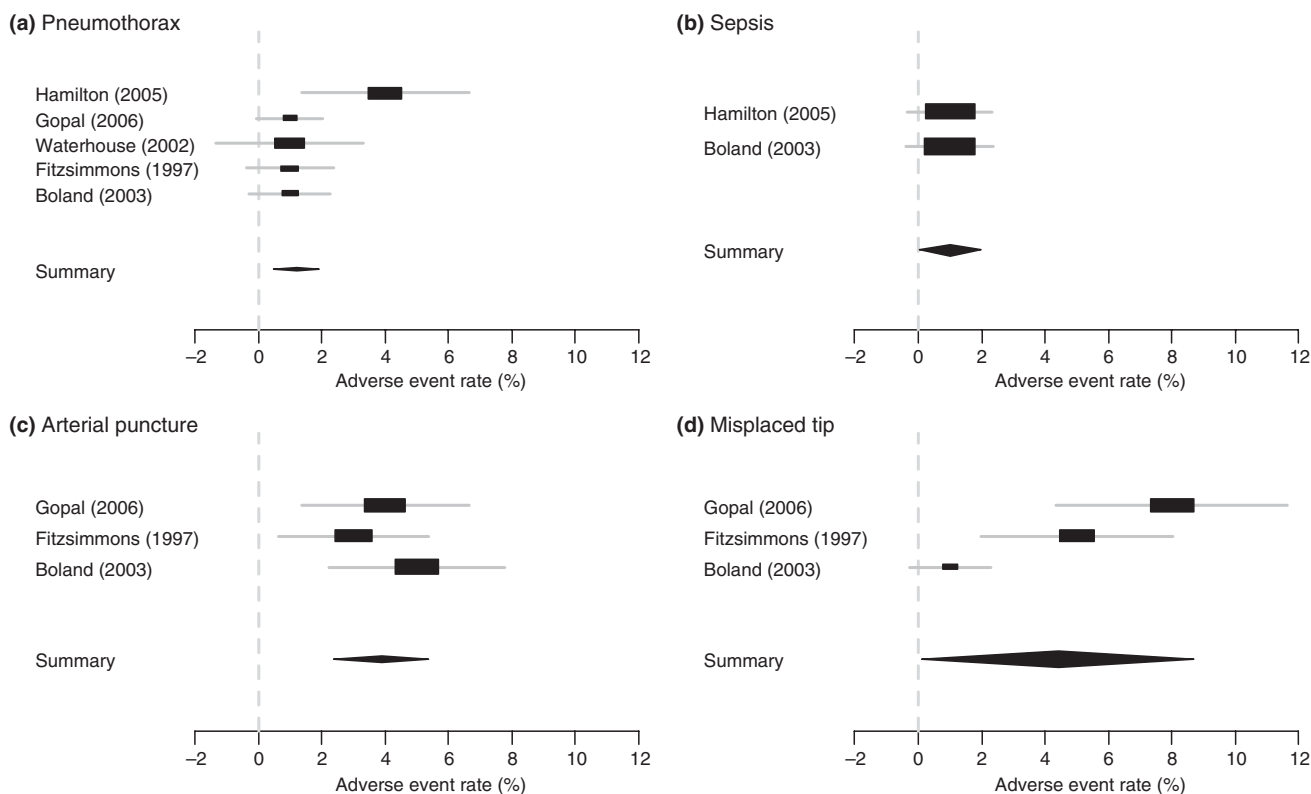


Figure 1 Forest plots depicting the four major complication rates reported.

established where a consultant anaesthesiologist was appointed as a tutor. The learning contract was multi faceted and involved supervised insertions of CVCs, review of anatomic structures associated with CVC insertions, clinical examination and assessment, chest x-ray interpretation and advanced cardiac life support.

This training process was similar to that discussed by Gopal *et al.* (2006) in relation to their CVC service development. They discussed the training process involved 50 central line insertions, observation of trainers inserting CVCs and formal assessment (Gopal *et al.* 2006).

Guidelines for the scope of practice were discussed by Fitzsimmons *et al.* (1997), this including acceptable haemoglobin levels and coagulation profiles. Operating protocols were developed as part of the nurse led service which was established by (Kelly 2003). Competency standards were developed and accreditation was gained where standards were met, this included essay writing, oral discussion with trainers and practical assessment. Standard operating protocols were developed similar to that of Fitzsimmons *et al.* (1997) and extended to patient referrals, consent for procedure, sedation and patient information.

Benton and Marsden (2002) discussed how a two part training and credentialing process was developed through the hospital operating protocols. The training incorporated a theoretical component on anatomical structures, basic physics of ultrasound and pharmacology. The practical aspects of the training involved supervised practice sessions on an *in-vitro* model (turkey breast), then supervised insertions.

Discussion

Implications for nursing practice

Advanced practice nursing is emerging as an important strategy in improving patient safety and improving patient health outcomes. The insertion of a CVC by a trained specialist nurse clinician may promote efficiencies and potentially minimise adverse events. The training methods for nurse clinicians as discussed by Gopal *et al.* (2006), Waterhouse (2002), Hamilton (2004a) and Kelly (2003) emphasise that appropriate training and supervision along with standard operating protocols can decrease rates of adverse outcomes including risks of insertion and the reduction of CVC associated infection rates. It is apparent that close cooperation and support from medical colleagues is essential and the accessibility to mentorship and clinical supervision is critical for developing these advanced practice clinical roles.

Educational facilities and course developers need to also take into account or be mindful of current clinical need, the

health care context and stakeholder needs in course developments. It is also important that course developers take into account the complexity and dynamic health care system and develop advanced practice nurses with analytical skill that can be used within their scope of practice (Chornick 2008). In order for this to occur, courses need to be developed to support emerging advanced practice roles. The process employed by Waterhouse (2002) in the development of a post graduate course reflecting the advanced role undertaken by specialist nurses is one example.

The implications for further training in the management of complications from CVC placement should be addressed as part of a clinical credentialing program. In particular in clinical facilities where appropriate 24 hours medical cover (such as rural and regional hospitals) is not available, a clinician should be available to manage complications such as inter-costal catheter placement for pneumothorax and first line treatment in case of a medical emergency.

Implications for health policy and research

Workforce shortages with junior medical officers and increased compartmentalisation of specialities will increasingly challenge the practice boundaries between traditional nursing and medical roles. How this is managed within a regulatory framework is yet to be clearly defined. On the basis of reported cases of advanced practice nursing roles in CVC insertion, it appears the support of local medical specialists is an important component for local policy development.

The blurring of accountability between advanced practice nurses and medical clinicians will need to be an important component in the development of local policy and government legislation. Local policies and operating protocols such as those discussed by Kelly (2003) are an example of how health policy at a local level has been tailored to ensure that a nurse specialist providing a crucial role within the hospital is legally covered to practice.

Strengths and limitations

A clear limitation of this review is the small number of studies, they are quasi experimental in design, precluding definitive conclusions. The fact that all the articles were from the UK has allowed for the confounder of health care system characteristics. It may be that there are many more nursing roles in existence but were not accessible using the search strategies described above. The comparison of studies presented was challenged by the heterogeneity of methods. We recognise the limitations in comparing adverse event rates

across different study populations. However, we think this is a critical step in developing benchmarking criteria for advance practice nursing roles in CVC insertion. The exclusion of articles related to PICC line insertion is both a strength and a weakness. Excluding these articles has potentially excluded discussion of advanced practice nursing roles in vascular access. However the focus of this review pertained specifically to the nursing role in CVC insertion. In spite of this, the review was undertaken using a prospective and systematic process clearly documenting implications for policy, practice and research.

Conclusion

This article describes an emerging practice area with important considerations for policy, practice and research. The studies discussed in this article have described the evolution of the advanced practice roles and the mechanisms for training and credentialing. Traditionally, inserting a CVC has been the domain of a medical practitioner, and articles discussing the role of nurses inserting CVCs described the transition to a collaborative, interdisciplinary model. There is a need to undertake well-conducted clinical studies to clearly document the value and efficacy of this advanced practice nursing role. Generating normative data in key diagnostic groups will facilitate benchmarking as well as undertaking of quality improvement initiatives. When complication rates are reviewed as an overall performance indicator for advance practice nurses inserting CVCs, the rates are similar to the wider and largely medical literature. These data are encouraging and underscore the value of the careful description and development of this advanced practice nursing role.

Finally, an important conclusion is that successful implementation of such an advanced practice nursing role is dependent on obtaining specialised knowledge and skills through the support of senior medical colleagues particularly for education and mentoring.

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Contributions

Study design: EA, PD, KH; Data collection and analysis: EA, TS, SF, PD; Manuscript preparation: EA, PD, MP.

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CHAPTER THREE

Publication Title: Establishing a Nurse-Led Central Venous Catheter Insertion Service

Chapter two discussed the evidence available on nurse led CVC insertion and its implications for nursing practice, health policy and research. This chapter reports on the establishment of a nurse led central venous catheter insertion service. In particular, the chapter gives a historical account of the barriers and facilitators encountered when the service was first developed in a teaching hospital situated in south western Sydney, Australia. This manuscript supports previous published reports that one of the main drivers for this model was shortage of trained medical staff to safely insert these devices and the need to improve hospital efficiency.

This chapter introduces the article presented as an original reprint article published in the *Journal of the Association for Vascular Access* (2010) Volume 15, Issue 1, Pages 21 – 27. (Impact factor 0.97)

Background

Adverse events associated with CVC insertion can have deleterious effects on patient outcomes. Procedural experience, good training and adhering to evidence based guidelines with CVC placement has been reported to improve insertion outcomes and reduce intravascular infection (Comfere & Brown, 2007; H. Hamilton, O'Byrne, & Nicholai, 1995; Mermel et al., 2009; Taylor & Palagiri, 2007).

Specialty nurses have illustrated improved or comparable clinical outcomes with their medical counterparts in a variety of specialties including vascular access (Alexandrou et al., 2010; H. Hamilton, et al., 1995; Ritz et al., 2000; Ryden et al., 2000). A major advantage of nurse led care has been the reported improvement in organisational efficiency. This is also true for nurse led CVC placement with reduced waiting times for catheter placement and treatment, reduced number of repeated catheter placement attempts and reduced length of hospital stay (Alexandrou, et al., 2010; Fitzsimmons et al., 1997; H. C. Hamilton, 2005; Waterhouse, 2002).

Aim of the study:

The study objective was to report on the establishment of a nurse led central venous access service (CVAS) in a university affiliated hospital situated in south western Sydney, Australia. The aim was to identify major barriers and facilitators to establishing such a unique service within a hospital. The study reported the background for service development by analysing archival information such as minutes of meetings, emails and interviewing key stakeholders using thematic and content analysis (Joffe & Yardley, 2003; Marconi & Rudzinski, 1995).

Thematic content analysis provided the ability to assess archival information including departmental communication as well as semi structured questionnaires for any recurring themes on the topic of interest. Due to only a small number of communications still available no systematic coding was necessary to conceptualise the results. It was evident that the main driver for this innovative model of care was medical staff shortages and their flow on consequences to the organisation.

Brief results of the study:

The CVAS was established in 1996 and has since increased in service provision. Because of the scepticism and scrutiny from some medical staff about a nurse performing such a role, a structured educational and credentialing process was developed. The nurses in the service were required to undertake didactic teaching and were supervised until 20 successful insertions of each major anatomical site. The CVAS has improved efficiencies with central venous access within the hospital including junior medical staff training and parenteral nutrition across the hospital. The report identified senior medical and management support was crucial in successfully implementing such a model.

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Establishing a Nurse-Led Central Venous Catheter Insertion Service

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Abstract

Background: Health care systems promote care models that deliver both safety and quality. Nurse-led vascular access teams show promise as a model to achieve hospital efficiencies and improve patient outcomes.

Objectives: The aim of this paper is to discuss the process of establishing a nurse-led central venous catheter (CVC) insertion service in a university affiliated hospital using a process evaluation method.

Method: Archival information, including reports, communications and minutes of departmental meetings were reviewed. Key stakeholders involved in establishing this nurse-led service at the time were interviewed.

Results: A nurse-led CVC insertion service was first established in 1996 and has increased in service provision over 13 years. Initially there was scepticism from some medical practitioners about the feasibility of a nurse performing a traditional medical procedure. The service currently provides central venous access across the hospital including critical care areas. The service places up to 500 catheters per annum.

Conclusions: Establishing a nurse-led CVC insertion service has increased organizational efficiencies and provided an infrastructure for support of best practice. The support of senior management and medical practitioners was crucial to the successful implementation of this model of care.

Introduction

Central venous catheters (CVCs) are commonly indicated for intravenous medications unsuitable for peripheral administration (Horattas et al., 2001) and have traditionally been placed by medical practitioners. The insertion of CVCs has become a common outpatient procedure for the administration of medication in the community setting, particularly for chemotherapy and parenteral antibiotic administration. They can be inserted via the central veins or via peripheral access (peripherally inserted central catheter - PICC) (Sharpe, 2006). Adverse events related to CVC insertion have been reported to be as high as 15% (Taylor & Palagiri, 2007) and serious complications can have an associated mortality as high as 47% (Comfere & Brown, 2007).

Experience by the health care professional is important in reducing CVC insertion complications. An experienced professional who has inserted more than 50 CVCs is estimated to have half the complication rate of one that has inserted fewer than 50 (Taylor & Palagiri, 2007). Achieving this experience

can be challenging when clinicians have multiple roles and responsibilities. Nurse-led models for CVC insertion have shown promise in addressing workforce shortages of medical practitioners and improving health outcomes that are related to specialization (Alexandrou et al, 2009).

Increasingly, advanced nurse-led models of care have improved patient outcomes across a range of clinical areas in many health care settings (Cowan et al., 2006; Ritz et al., 2000; Ryden et al., 2000). In a recent integrative review describing nurse-led CVC insertion services, it was found that they had been introduced to overcome delay in CVC insertion that had resulted from shortages of physicians. (Alexandrou, et al, 2009). Other reasons for introducing these services included unacceptable rates of infection, misplaced catheter tips; increased costs associated with repeat attempts by other physicians and increased length of stay (Fitzsimmons et al., 1997; Hamilton, 2004, 2005).

Patient outcomes from nurse-led CVC insertion compared well with published rates of common CVC insertion complications (Comfere & Brown, 2007; Boland, Haycox, Bagust, & Fitzsimmons, 2005; Casey & Davies, 2003; Goral, Fitzsimmons, & Lawrance, 2006; Kelly, 2003; Waterhouse, 2002).

In our hospital similar issues and concerns led to a nurse-led central venous access service (CVAS) being established in

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1996. The CVAS has remained in operation with over 4200 catheter placements. It currently employs two advanced practice nurses with critical care backgrounds who insert CVCs for hospital patients and assist in managing parenteral nutrition (PN) for patients outside the intensive care unit (ICU).

Aim

This paper aims to discuss the establishment of a nurse-led CVAS in a university affiliated hospital and presents the rationale for its implementation, the process of service development, the ongoing adjustment and the current status of the service.

Method

Setting

The site is a 650-bed university affiliated hospital in south west Sydney, Australia with major trauma, surgical and medical services. The hospital has a 28-bed Intensive Care Unit (ICU) which also provides a Medical Emergency Team (MET) response (Lee, Bishop, Hillman, & Daffurn, 1995).

Data

Analysis of archival information, such as reports, electronic communications and minutes of departmental meetings were undertaken using thematic content analysis (Marconi & Rudzinski, 1995; Smith, 1992). Key stakeholders from nursing, medicine and hospital administration involved in establishing this nurse-led service who were currently still employed in the hospital were interviewed using a semi-structured questionnaire (See Table 1).

Descriptive analyses of data generated from an administrative data set were undertaken to describe patient characteristics. Ethical approval for this study has been granted by the institution's human ethics committee for the protection of human subjects.

Results

Documents and reports were reviewed from 1996 and 1997. Staff identified as key stakeholders at the time of the CVAS development and who were currently still employed in the hospital (6 in total, 2 medical practitioners, 3 nursing personnel and 1 administrative staff member) were interviewed.

Rationale for service implementation

In the late 1990s, the hospital underwent significant re-development which impacted greatly on the workload of the ICU. This was compounded by its commitment to trauma services and the MET system. As the hospital grew in size, the ICU medical practitioners' capacity to provide a timely and efficient CVC placement service for non-emergent (ward-based) patients became less reliable. Patients from general wards requiring CVC insertion would be transferred to the ICU to a vacant bed area and the catheter placed by one of the ICU doctors. Often, because of competing work demands the patient would be transferred back to the ward without catheter placement. This delay resulted in frustration of patients and clinicians alike, with additional cost to ICU for the goods and services spent on procedural set up that were eventually not used.

The increased workload was complicated by the perception

Table 1. Sample questions for stakeholders

- What do you think was the impetus for setting up a nurse-led central line service?
- What were some of the strategies and processes used to implement the service?
- What barriers were faced and how were they resolved?
- What do you consider to be the facilitators to the service implementation?
- What were the administrative and funding concerns in service development?

from senior medical practitioners that there was less time to coordinate the supervision of junior medical practitioners in CVC placement due to increased demands on their time. Without standardized procedures or processes for monitoring of operator performance such as insertion complications and infection rates, it was not uncommon for patients to undergo multiple attempts for catheter placement.

The lack of an organized approach to monitoring and supporting PN also led to unnecessary delays and poor management. To address this problem, the ICU medical directors applied for funding through medical administration for an extra medical staff training position to assist with the workload. This application was declined due to lack of funding, and it was decided to use in-house resources and train a senior ICU nurse to undertake some duties to relieve medical staff workload.

The plan aimed to provide a dedicated person to coordinate CVC insertion at an organizational level, and improve efficiencies and outcomes. To ensure the nurse possessed the necessary knowledge and experience, certain pre-requisites for the role were identified. These included: a critical care background, critical care qualification, and peripheral venous and arterial cannulation skills. In December 1996, a dedicated Central Venous Access Service (CVAS), with an advanced practice nurse in the lead role, was created within the Intensive Care Department.

Service model

The service initially ran with one operator 3 days a week. It was soon apparent that the service demand warranted 5 day a week coverage. The service operated in this manner for 7 years, until in 2003 when a second nurse was employed to accommodate increased needs. Currently there are two advanced practice nurses who have been trained and credentialed to insert CVCs throughout the hospital. A third nurse is in the process of becoming credentialed to support the CVAS.

The service currently operates 5 days a week with a full-time equivalent (FTE) of 1.2 nurses. They report to the medical director of the ICU for administrative and clinical issues. Outcome data is reported to the ICU medical and nursing directors on a yearly basis as part of the performance appraisal process. The education role of the service includes hospital wide teaching for medical and nursing staff along with competency based

Table 2. Central venous catheter insertion competency assessment checklist

COMPETENCY ASSESSMENT CHECKLIST – Central Venous Cannulation (Landmark Technique)

Site of insertion: _____

The following criteria must be successfully achieved during assessment.
Unsuccessful attempts must also be recorded and assessed.

Criteria	Achieved <input type="checkbox"/> or <input type="checkbox"/> (or n/a)	Re-assessment (If required) &/or Comments
Candidates Name: _____		
Procedure		
Explains procedure to patient and obtains consent – if applicable		
Organizes equipment (ensure sharps container is on hand)		
Identifies patient and performs safety checklist		
Ascertain if patient has any allergies (e.g. to antiseptic solutions, local anesthetic agents or dressings)		
Assesses and selects suitable site for cannulation		
Prepares equipment and accessories for catheter insertion		
Positions patient to maximize access to desired area of insertion i.e. Trendelenberg position if required		
Attaches monitoring (ECG & SpO2)		
Applies protective equipment (gloves, mask & eyewear or face shield) as per standard precautions policy		
Washes hands using sterile hand-wash technique (2 mins)		
Prepares skin area appropriately (with antiseptic solution)		
Drapes patient with large sterile drapes to maximize sterile barrier		
Inspects catheter and equipment to ensure it is not damaged/remains intact & checks that the guide wire works		
Flushes/primes each lumen with 0.9% normal saline		
Palpates anatomical landmarks correctly		
Correctly anesthetizes skin and deeper tissue with local anesthetic		
Inserts cannula/needle with bevel facing upwards, advancing slowly while maintaining slight negative pressure with syringe		
Checks for “flashback” and advances guide wire to desired length		
Dilates skin and vessel with vessel dilator		
Inserts catheter over guide wire to desired or measured length whilst maintaining grip on guide wire at all times		
Removes guide wire & connects transducer line. Checks & acknowledges for NON-ARTERIAL waveform on monitor.		
Secures catheter at insertion site appropriately and applies sterile transparent occlusive dressing to insertion site		
Records date & time on dressing.		
Disposes all sharps material in sharps container		
Removes drapes and accessories from patient		
Correctly disposes general/contaminated waste materials		
Removes protective equipment and washes hands		
Documents procedure in patient’s health care record		

Date: / /

proficiency assessment in CVC placement for ICU medical trainees (See Table 2).

Characteristics of service delivery

From December 1996 to October 2008, 4212 catheters have been placed by the CVAS in 3055 patients. Two hundred forty six catheters were inserted in the first full year (1997). Since then the service has inserted up to 500 catheters per annum. The most common indication for catheter placement was for antibiotics (n=2598, = 61.7%), with the second highest indication being for oncology and autoimmune disorders (n=759, 18%). Over half (53%) of insertions used the subclavian vein while, the upper peripheral veins (for PICCs) were the next common (41.5%) access site. For the CVAS, these two routes of access represented just over 94% of total insertions. As an elective service, with minimal emergency insertions, the CVAS uses these two preferred anatomical sites to optimize catheter longevity and infection outcomes (Maki, Kluger, & Crnich, 2006). Characteristics of service are presented in Table 3.

Barriers and Facilitators to Service Implementation:

Four themes emerged from the data that identified barriers to service implementation: 1) opinions of medical clinicians, 2) medico-legal concerns, 3) risk minimization strategies, and 4) negotiating funding models.

Barriers:

Opinions of medical clinicians

While the intensive care physicians supported the concept, some other medical specialists expressed concern at nursing staff performing a procedure traditionally performed by medical practitioners. Initially, there was hesitation from surgeons who refused to refer their patients for CVC placement; and it took time before surgical patients were seen by the CVAS. Any incident was scrutinized for apparent deficiency in clinical skill or knowledge.

The medical directors of the ICU were required to intervene and assure other specialties that patient safety would not be compromised by making representation at specialty departmental meetings.

Medico-legal concerns

Medico-legal liability was a key concern and was discussed with both the hospital administration and the Medical Defence Union (MDU). While the MDU did not deny the feasibility of the role, it stated that there should be adequate training and protocols in place to prevent risk and that the procedure was to be scrutinized thoroughly before implementation. Once an appropriate training and credentialing program was developed, the hospital administration was satisfied and stated: “a nurse is covered by public and professional liability for performing this role as for any other healthcare professional working within the area health service.” (Sydney South West Area Health Service, 1996)

Risk minimization strategies

The risks associated with this service were seen to be a barrier to implementation. In order to facilitate quality and patient

Table 3. Characteristics of the CVAS

Patient Characteristics		
Number of Catheters	4,212	
Number of Patients	3,055	
Age mean (SD)	56 (19)	
Males %	58%	
Indication	%	(N)
Antibiotics	61.7	(2598)
Oncology / Autoimmune	18	(759)
Other	7.9	(332)
Poor Vascular Access	7.2	(305)
Parenteral Nutrition	5.2	(218)
Insertion Site	%	(N)
Subclavian	52.8	(2225)
Upper Peripheral Veins	41.5	(1748)
Femoral	3.6	(151)
Internal Jugular	2.0	(86)
Catheter Type	%	(N)
CVC	55.3	(2330)
PICC	38.9	(1635)
High Flow / Dialysis Catheter	3.5	(149)
Midline	2.2	(92)
Clinical Category of Patients	%	(N)
Medical	55.2	(2325)
Surgical	43.5	(1831)
Women & Child Health	1.0	(42)
Critical Care	0.3	(14)

safety and comply with the medico-legal obligations for the hospital, operating protocols were developed in consultation with medical specialists and introduced as part of a formal hospital wide policy and procedures program. Part of the operating protocol development included documentation and practice around coagulation levels; ensuring that consent was valid; and the monitoring of patients during procedure with pulse oxymetry, cardiac monitoring and confirming catheter position by venous waveform and radiology.

The operating protocol stipulated that senior ICU medical staff in the ICU at the time of line placement would be available for assistance if required. More recently with the availability of ultrasound guidance, the CVAS has used this technology where appropriate to facilitate vascular assessment and access.

Negotiating funding models

Funding for the service was an issue and required the ICU medical and nursing directors to think laterally. The eventual funding model involved a collaborative approach. The ICU accepted the fiscal responsibility for the nurse position as well as physically housing the service within an ICU office. As the service was developed in response to ward patient need, agreement was made between specialties that billing for consumables would be made to the clinical division for which the patient was assigned. A database was also developed at the inception of the service so that a record of all patients who had a CVC placed by the CVAS would be recorded and archived to facilitate billing, research and quality improvement.

Facilitators:

In response to the challenges discussed above a number of facilitators were also identified including: 1) clinical leadership, mentoring and education, 2) organizational support; 3) outcome assessment and quality assurance

Clinical Leadership, mentoring and education

As with most programs of change, clinical leadership and support was integral. Senior nursing and medical staff from the ICU had a vision and enabled it. Education and accreditation processes were implemented within a collegial framework. This format provided a standardized approach for catheter placement that would reduce catheter insertion complications and also reduce CVC associated bacteremia. A learning program was developed that included theory, clinical teaching and competency based assessment.

The theoretical component involved tutorial and bedside teaching for the nurse by ICU physicians, including anatomy and physiology, contraindications for catheterization, intra-procedural problems, as well as post insertion complications and treatment. An oral viva (a method of examination where students are asked a question by an examiner and are required to verbalize the answer) was used to assist in the theoretical assessment along with a written examination that included multiple choice and short answer questions.

As part of the program, the nurse observed ICU physicians insert CVCs; then, inserted 20 CVCs under direct supervision, including subclavian, internal jugular, femoral, and upper peripheral vein approaches using competency based proficiency assessment. All attempts at the time were recorded as part of the credentialing process. Pre- and post-procedure debriefing occurred as part of the supervised insertions with ICU physicians that included review of abnormal anatomy, physiological anomalies such as deranged coagulation and previous medical history. Chest x-ray interpretation for optimal catheter tip placement and review for pneumothorax also formed an important component of the practical assessment. Over time this model became a framework for junior medical staff training.

Organizational support

Initial scepticism and hesitancy related to the service was balanced by significant support by a range of other professionals, including administrators, nurses from the ICU and the gen-

Table 4.
CVAS calling criteria

- Patients requiring intravenous access for longer than 2 weeks
- Patients needing specific IV drug therapy that is phlebogenic (e.g. chemotherapy / Parenteral Nutrition / IV antibiotics / IV medication with pH<6.5)
- Patients with poor vascular access
- Patients with a blocked Central Venous Catheter (CVC) lumen
- Patients that have signs of infection who have a CVC insitu
- Patients that have pain associated with the CVC
- Any other issues related to a CVC

eral wards. The achievement of organizational efficiencies and the recognition by clinicians that a single point of contact was available for advice and support quickly led to an organizational shift in attitude.

Key stakeholders such as the general manager of the hospital at the time were integral in service success by giving the position full support. A key facilitator also has been prominent CVAS representation at hospital orientation for new medical and nursing staff and the routine education of existing clinical staff. This role has facilitated a cultural and attitudinal change within the hospital.

Prospective methods for outcome assessment and quality assurance

The CVAS primarily provides an elective (non emergent) catheter placement service with dedicated follow-up and consultation. Time is invested in data collection, collation and review of outcomes on a regular basis so that there is a continuous quality improvement program for vascular access within the hospital. This has led to an infrastructure for monitoring of patients with CVCs across the hospital and as such, there is a defined contact point for clinical staff that have enquiries concerning vascular access devices (VADs). In addition, clinicians have access to specialists in central venous access who have the ability to address catheter issues and as a consequence increase catheter longevity (See Table 4).

The structured competency based approach to clinical assessment and outcome review has given external organization prominence for the CVAS and is seen as a key opinion leader in dedicated central venous access services within Australia. The competency based approach for CVC assessment has been adopted as a framework for a state-wide project within New South Wales (NSW). The central line associated bacteremia (CLAB) project run by the Clinical Excellence Commission (CEC) in NSW has involved the CVAS in many aspects of the project

Table 5. Advantages of a nurse-led CVAS

- Allows timely response to requests for elective CVC insertions that may be delayed due to the acute care focus of anesthetic and critical care services
- Provides an infrastructure for support of CVC best practice across the organization
- Facilitates individualized patient assessment and continuity of care
- Affords capacity for data collection and management to monitor for clinical outcomes
- Presents a framework for interdisciplinary collaboration

which has aimed to reduce CLABs and promote quality and safety in central venous access (Clinical Excellence Commission).

Current operational aspects of the CVAS

The CVAS uses a cart that stocks all consumables including a variety of CVCs. The trolley is wheeled to any one of the 28 bed spaces in the ICU that may be vacant and available to use for catheter placement. If all ICU beds are occupied which sometimes occurs, the trolley allows the service to be more mobile and provide the service at the ward bedside. In cases where CVC insertion occurs at the ward bedside, a portable monitor is used.

During hospital orientation and mandatory education days, new hospital clinical staff are educated about the CVAS and what services it can provide. The CVAS provides training and accreditation on the insertion of CVCs for medical trainees joining the ICU. These staff are expected to complete a workbook and questionnaire prior to being assessed clinically. Clinical accreditation involves competency-based assessment. (See Table 2). Once the medical trainees have been accredited they are permitted to insert CVCs within the ICU.

The nurses in the CVAS are contacted by phone and by pager. Ward nursing staff are encouraged to contact the CVAS if they identify a patient whom they feel will benefit from a CVC and in cases like these the CVAS acts as a consultancy to the admitting team advising of the best VAD for the patient (See Table 5). Patients are brought to a vacant bed area in the ICU by the hospital ward orderly department. Prior to commencement of procedure the patient is given information regarding the procedure; clinical notes are checked for a valid consent form. A number of pre-insertion checks are undertaken and documented such as a brief review of clinical history and presenting problems of the patients. The medication chart is reviewed to ascertain any medications that may influence the safety of the procedure and the electronic records are then reviewed for recent pathology results including platelet count and coagulation profile (See Table 6).

Most CVC insertion requests are actioned within 24 hours. Typically catheter placement is undertaken either the same day or the following day dependant on service activity and the time of initial phone consultation. The CVAS is responsible for all

Table 6. CVAS pre-insertion check criteria

- Valid signed informed consent
- Consultation form
- APTT 35 – 45 seconds (Activated Partial Thromboplastin Time)
- INR <1.5 (International Normalised Ratio)
- Platelets > 50,000 x 10⁹ / L
- Oxygen requirements (Litres / Minute)
- Anticoagulant medication (Type / Dose)
- Allergies (Type / Response)
- Is this a high risk patient (such as abnormal body habitus)?
- Availability of senior ICU medical staff if required

patients who are receiving PN outside of the ICU. Patients are reviewed daily and solution rate is adjusted accordingly. The CVAS works in conjunction with a senior ICU doctor, a pharmacist and a dietician to manage patients that are on PN. This multidisciplinary approach has enabled a more effective approach to PN and also ensures that patients are monitored more closely with daily assessment and review.

The service has continued to evolve and develop in response to therapeutic advances. In recent years, the role of ultrasound and its benefits have greatly influenced how vascular access is attained (French, Raine-Fenning, Hardman, & Bedforth, 2008; Verghese et al., 1999). Both nurses within the CVAS have undergone formal training in the use of ultrasound and this technology has improved vascular assessment and in aiding catheter placement where appropriate.

Discussion

This review has provided an historical account of the implementation of a nurse-led CVAS and in particular, the challenges faced and how these were overcome. Our nurse-led CVAS was developed out of increased organizational workload and the need to improve staff skill mix. The concept of a nurse-led CVAS required cultural change within the hospital. Full acceptance took time to achieve. Clinical and organizational leadership from senior clinical and administrative staff played a significant role in the success of the service.

Conclusion

The CVAS has been well accepted and widely used since its inception in 1996. The service is used across hospital settings including general wards, operating theatres, the Emergency Department and the ICU. The implementation of the CVAS has challenged traditional organizational and professional boundaries to improve patient care and capacity to monitor patient outcomes. The CVAS staff are involved extensively in education, quality improvement, research and policy development at

a local, state and international level. This evaluation has demonstrated that through systematic attention to barriers and optimizing enabling factors, innovative, nurse-led service models can be promoted to improve patient care.

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Summary of key points:

- Workforce innovation and multidisciplinary care can have positive patient outcomes and improve organizational efficiencies.
- Implementing an advanced nurse-led clinical practice model can be confronting to medical practitioners. It is vitally important that key clinicians within an organization assist to champion the role.
- Critical care nurses with their broad clinical and assessment skills are ideal candidates for such an advanced practice role.
- Having a nurse-led CVAS that is skilled in various vascular accesses techniques, can lead to a broad range of patients across the hospital being seen and therefore making the service an important adjunct to the organization.

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CHAPTER FOUR

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

The previous chapter discussed in depth, the establishment of a nurse led central venous catheter insertion service giving a historical account of the barriers and facilitators encountered when the service was first developed. This chapter provides supporting evidence that vascular access specialists can insert the best available device to suit the patient's needs. It promotes the notion that different vascular devices can be used for different therapeutic purposes.

An integrative literature review method was used to identify the best possible evidence regarding the use of midline catheters. These catheters can be used for extended periods of intravenous therapy without requiring repeated peripheral cannulation and provides recommendations for their use in the acute care setting.

This chapter introduces the article presented as an original reprint published in the *Journal of the Association for Vascular Access* (2010) Volume 15, Issue 1, Pages 21 – 27. (Impact Factor 0.97)

Background

Vascular access is required for the administration of many parenteral medications. Selection of the most appropriate device involves timely assessment and planning. Vascular access in many hospitals has historically been a reactive process. Clinicians with good intention but with minimal background knowledge would insert whichever device is immediately available without consideration of the patient's vasculature, the acidity or osmolarity of the solution being administered (Hecker, 1989; Hoefel, Lautert, Schmitt, Soares, & Jordan, 2008; How, 1998; Moureau et al., 2012).

Often, such reactive clinical decision making leads to peripheral cannulation that is painful and eventually futile as it leads to the exhaustion of peripheral

veins when other devices would be more suitable. Vascular access specialists can use clinical pathways or decision matrices' to ensure the most appropriate device is inserted that is suited to the patients vascular anatomy, diagnosis and treatment plan (Hawes, 2007; Kokotis, 1999).

Midline catheters are intermediate term devices that are inserted in the upper peripheral vessels above the antecubital fossa. The catheter is usually 20cm in length and terminates at the axillary vein. Although not a central venous catheter, it provides better dilution and distribution of medication compared to a peripheral cannula. This device can reduce the risk of phlebitis and infiltration that can occur with medication administered through a peripheral cannula. Midlines have the added benefit of having increased dwell time (4-6 weeks compared to a peripheral cannula which is 96hrs). This increase in dwell time significantly reduces the number of needle sticks the patient will require that will reduce anxiety, pain and ultimately maintain vessel health and reduce infection (Catton et al., 2006; Gorski & Czaplewski, 2004; Harwood, Greene, Kozakowski-Koch, & Rasor, 1992).

Aim of the study:

The intention of this study was review the best available evidence of the use of midline catheters for adults in the acute care setting and to synthesise recommendations for clinical practice. An integrative literature review was used because of the heterogeneity in study design which precluded the ability to undertake a meta-analysis (Goldsmith, Bankhead, & Austoker, 2007; Whittemore & Knafl, 2005).

Brief results of the study:

The review found both positive and negative aspects for the use of midline catheters but have a role to play in many patient cohorts and in particular have significant advantages in reducing multiple peripheral cannulations. Midline catheters can also be used in place of a central venous catheter which therefore reduces procedural risk and avoids the need for a chest x-ray. The review

identified that although midlines have been associated with an increased risk of phlebitis and are not suitable for patients with compromised venous circulation, they can be placed in many patient cohorts.

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

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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.

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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 & Czaplowski, 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 approxi-

mately 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 & Czaplowski, 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 & Czaplowski, 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 & Czaplowski, 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 & Czaplowski, 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 & Czaplowski, 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 & Czaplowski, 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 & Czaplowski, 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 & Czaplowski, 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 & Czaplowski, 2004; Griffiths, 2007). Gorski and Czaplowski (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 & Czaplowski, 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 & Czaplowski, 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 & Czapslewski, 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 & Czapslewski, 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 & Czapslewski, 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 & Czapslewski, 2004; Griffiths, 2007). Gorski and Czapslewski (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 & Czapslewski, 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 & Czapslewski, 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, cephalosporin 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 osmolality <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, osmolality should be less than 850mOsm/L and vigilant monitoring is essential (Pittiruti, Hamilton, Biffi, MacFie & Pertkiewicz, 2009). Matsumoto, Shirohara and Kameoka (1999) agree that midline catheters are safe for the administration of parenteral nutrition, optimally with an osmolality 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

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

Recommendations for insertion:
<ul style="list-style-type: none"> • 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:
<ul style="list-style-type: none"> • 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:
<ul style="list-style-type: none"> • Patients at risk of thrombosis. • Patients with compromised circulation. • Patients at risk of lymph oedema. • Patients with end stage renal disease requiring vein preservation.

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.

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.

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CHAPTER FIVE

Publication Title: Central venous catheter insertion by a clinical nurse consultant or anaesthetic medical staff: a single-centre observational study

Chapters two, three and four synthesised the best available literature relating to nurse led central venous catheter insertion, the establishment of a nurse led central venous catheter insertion service and the advantages of such services being able to titrate the vascular access device to patient need where midline catheters were explored as an exemplar. This chapter begins to provide the supporting evidence that nurse led central venous access is a viable model of care and has particular advantages such as reduced procedural complications and catheter related blood stream infection compared to medical staff catheter placement.

This chapter introduces the article presented as an original reprint published in the *Critical Care and Resuscitation: Journal of the Australasian Academy of Critical Care Medicine*, (2010) Volume 12, Issue 2, pages 90 – 95. (Impact Factor 1.51)

Background

In Australia, central line associated bacteraemia is reported to have an incidence of 3500 episodes annually with an associated mortality of 12% (Department of Human Services, 2005). Procedural complications from central venous catheter placement also pose significant morbidity and mortality risks. As such procedural experience and good training are important factors that will contribute to procedural success (Remes, Sinisaari, Harjula, & Helenius, 2003; Taylor & Palagiri, 2007). There have been examples of advanced practice nurses undertaking clinical procedures that were previously done by medical practitioners that have showed equivalent patient outcomes (Ritz et al., 2000; Ryden et al., 2000; Wright, 1997).

Nurse led central venous catheter placement can potentially reduce procedural risk and intravascular infection by expertise generated through volume and adhering to evidenced based guidelines. Prior to this publication, no comparative outcome data had been published between medical practitioners and specialised nursing staff.

Aim of the study:

Our study objective was to compare clinical outcomes of elective central venous catheter insertions performed by a clinical nurse consultant or anaesthetic medical staff. This prospective observational study reviewed consecutive CVC insertions between July 2005 and October 2007.

Brief results of the study:

In a 28-month period, a total of 245 CVCs were inserted by anaesthetic medical staff and 123 by the CNC. The most common indications for CVC placement in both groups were for the treatment of oncology and autoimmune disorders (61%). There was no significant difference in complications on insertion between the two groups. The rate of CVCs investigated for infection was twice as high with anaesthetic medical group. Importantly the confirmed catheter-related bloodstream infection (CRBSI) rate was 2.5/1000 catheters in the anaesthetic medical group compared to 0.4/1000 catheters in the CNC group ($P = 0.04$).

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Central venous catheter insertion by a clinical nurse consultant or anaesthetic medical staff: a single-centre observational study

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Catheter-related bloodstream infections (CRBSIs) related to central venous catheters (CVCs) are associated with increased morbidity, mortality and health care utilisation.^{1,2} A CRBSI is defined by the United States Centers for Disease Control and Prevention (CDC) as a bloodstream infection in a patient who has a CVC in place, for which other sources of infection have been excluded by examining patient clinical records, and where a culture from a portion of the catheter has demonstrated substantial growth of an organism identical to those found in the bloodstream.³

In Australia, the reported incidence of CRBSIs is over 3500 annually, with an associated mortality of 12%.⁴ Nurse-led clinical services, such as those in gerontology and oncology, have been shown to improve patient safety and hospital efficiency.⁵⁻⁷ Nurses trained in inserting CVCs have the potential to reduce catheter-related complications and reduce CRBSI.^{8,9} Factors that enhance favourable outcomes include operator expertise, adherence to standardised protocols, and high procedural volume by individuals.¹⁰⁻¹²

The aim of our study was to compare the characteristics and clinical outcomes associated with CVC insertion by a clinical nurse consultant (CNC) and anaesthetic medical staff (AMS) within the same hospital.

Methods

Design, setting and participants

We conducted a prospective audit of a convenience sample of consecutive CVC insertions performed between July 2005 and October 2007 at a university-affiliated hospital in Sydney, Australia. The facility provides a range of acute, chronic and outpatient services. Historically, CVCs were inserted by the medical staff from the anaesthetic department for both inpatients and outpatients. Increasing demands for catheter placements and limited availability of anaesthetists led to the implementation of a nurse-led model for CVC insertion. In 2005, a critical care nurse who was based in the intensive care unit and had experience with peripherally inserted central catheter insertion was recruited to undertake this role. All CVC insertions included in our study, regardless of operator, were elective procedures. The CVCs were inserted in a general recovery room

ABSTRACT

Objective: To compare clinical outcomes of elective central venous catheter (CVC) insertions performed by either a clinical nurse consultant (CNC) or anaesthetic medical staff (AMS).

Design, setting and participants: Prospective audit of a convenience sample of consecutive CVC insertions between July 2005 and October 2007 at a metropolitan teaching hospital in Sydney, Australia. The sample included all outpatients and inpatients requiring a CVC for either acute or chronic conditions.

Main outcome measures: Number of CVC lines inserted; differences between outcomes in the CNC and AMS groups; complications during and after insertion.

Results: Over a 28-month period, 245 CVCs were inserted by AMS and 123 by the CNC. The most common indications for CVC placement in both groups were for the treatment of oncology and autoimmune disorders (61%) and for antibiotic therapy (27%). Other indications were parenteral nutrition (2%) and other therapies (10%). There was no significant difference in complications on insertion between the CNC and AMS groups. AMS failed to obtain access in 12 attempted procedures compared with eight by the CNC. The rate of CVCs investigated for infection was twice as high in the AMS group as in the CNC group (19% v 8%). The confirmed catheter-related bloodstream infection (CRBSI) rate was 2.5/1000 catheters in the AMS group and 0.4/1000 catheters in the CNC group ($P=0.04$).

Conclusion: Insertion outcomes were favourable in both the AMS and CNC groups. Infection outcomes differed between groups, with a higher rate of CRBSI in the AMS group.

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adjacent to the operating room, using similar products, equipment and standardised protocols.

Post-insertion CVC care was carried out according to hospital protocols and was not controlled for. This care included changing transparent occlusive dressings using an

aseptic technique twice weekly, or more frequently if the dressing's integrity was compromised. The skin was cleaned by using an alcohol-based chlorhexidine solution and applying a chlorhexidine-impregnated disk at the catheter insertion site.

Catheter type and site of insertion were also not controlled for, varying according to the decision of the operator at the time and based on clinical assessment, operator preference and catheter availability. In addition, the hospital's microbiology department stipulated that antibiotic-coated catheters were to be inserted only in patients at high risk of catheter-related infection. This included all patients receiving parenteral nutrition; those undergoing heart, renal, lung or stem-cell transplantation; or those having prolonged antibiotic or cytotoxic therapy (> 11 days).

Data collection

Routine data collected included age, sex, indication for catheter insertion, and type of catheter used. Data were then entered into an electronic spreadsheet. All microbiological

testing of catheters (CVC tip and blood cultures) after insertion was reviewed, and information was categorised to ascertain clinical outcomes using a standardised data extraction tool (Appendix).

Patients were classified into five groups according to the indication for catheter insertion: oncology and autoimmune disorders, parenteral nutrition, antibiotic therapy, drug therapy (excluding antibiotics), and other (any indication not related to the other four groups). Catheter dwell time was calculated as the interval between the date of insertion and the date of removal (the date the CVC tip was sent for microbiological investigation and culture).

Complications associated with insertion were divided into nine categories: uneventful (no complications on insertion), multiple passes, arterial puncture, failed venous access, misplaced CVC tip, difficult feed of the catheter or guide wire, difficult venous access, pneumothorax and haematoma. Catheter-related thrombosis (the development of a thrombus in the catheterised vein)¹³ was used as a long-term outcome.

Infection data on CVCs after removal were divided into three categories: (a) no sign of infection, with no peripheral blood or CVC tip sent for culture; (b) no sign of infection, with the CVC tip only sent for culture (this was routine practice for some ward areas [eg, oncology]); and (c) signs of infection where the CVC could not be excluded as a source, with both the CVC tip and peripheral blood sample sent for culture (this was used to diagnose CRBSIs according to CDC guidelines).³

Table 1. Group characteristics

	Clinician type		P*
	Anaesthetic medical staff	Clinical nurse consultant	
Catheters inserted, <i>n</i>	245	123	
Patients, <i>n</i>	148	84	
Mean age in years (SD)	50 (15)	49 (18)	0.59
Male sex, <i>n</i> (%)	130 (53%)	75 (61%)	0.12
Indications for insertion, <i>n</i> (%):			
Oncology and autoimmune disorders	145 (59%)	81 (66%)	0.24
Parenteral nutrition	6 (2%)	3 (2%)	0.99
Antibiotic administration	74 (30%)	27 (22%)	0.09
Drug therapy	9 (4%)	3 (2%)	0.52
Other	11 (4%)	9 (7%)	0.25
Insertion site, <i>n</i> (%):			
Internal jugular	125 (51%)	81 (66%)	<0.01
Subclavian	115 (48%)	42 (34%)	<0.01
Femoral	5 (2%)	0	0.11
Catheter type, <i>n</i> (%):			
Vascath	29 (12%)	18 (15%)	0.55
Single lumen	42 (17%)	24 (20%)	0.68
Double lumen	23 (9%)	4 (3%)	0.06
Triple lumen	151 (62%)	77 (63%)	0.95

* Continuous data analysis using *t*-test and categorical data analysis using Fisher's exact test.

Table 2. Catheter characteristics

Catheter type, <i>n</i> (%)	Clinician type		P*
	Anaesthetic medical staff	Clinical nurse consultant	
Antiseptic-coated catheter (first-generation) [†]	123 (50%)	78 (63%)	0.01
Antiseptic-coated catheter (second-generation) [‡]	81 (33%)	3 (2%)	<0.01
Antibiotic-coated CVC	7 (3%)	22 (18%)	<0.01
Non-coated CVC	27 (11%)	20 (16%)	0.16
Tunnelled CVC (non-coated)	7 (3%)	1 (1%)	0.24

CVC = central venous catheter. * Categorical data analysed using Fisher's exact test. † Catheters coated with chlorhexidine and silver sulfadiazine on the external surface of the catheter only. ‡ Catheters coated with a three-fold increase in the concentration of chlorhexidine and silver sulfadiazine on the external surface of the catheter (incorporates coating of the luminal surface, extension and hubs of the catheter).

Statistical analysis

Descriptive statistics are presented as frequencies and proportions. Details of patient demographics, indications for insertion, site of insertion and type of line were documented for the CNC and AMS groups. Differences in outcomes between the two groups were also assessed using the Student *t*-test for analysis of continuous data and the Fisher's exact test for categorical data. The comparative incidence of CRBSIs was calculated using a χ^2 distribution. We were unable to capture catheter-days for the CVCs that were not sent for microbiological testing. The comparative incidence of CRBSIs was therefore calculated per 1000 catheters.

Results

Between July 2005 and October 2007, 232 patients had a CVC placed by either the CNC or AMS (of which there were 40 altogether). A total of 368 CVCs were inserted, with some patients having multiple insertions (range, 1–8) (Table 1). The mean age of patients was similar in the AMS and CNC groups (50 years and 49 years, respectively; $P=0.6$); There were more males in the CNC group (61% v 53%), but the difference was not significant ($P=0.1$). The average catheter dwell time was similar in both groups (19 days and 21 days, respectively). There were 123 CVCs inserted by the CNC and 245 inserted by AMS. The difference in the number of catheters between the two groups relates to the availability of either operator at any given time during the study period, and was the major reason why a convenience sample was used.

Table 3. Outcomes on insertion of central venous catheters (CVCs)

Complications on insertion, <i>n</i> (%)	Clinician type		<i>P</i>
	Anaesthetic medical staff	Clinical nurse consultant	
Uneventful	194 (79%)	96 (78%)	0.91
Multiple passes	18 (7%)	5 (4%)	0.32
Arterial puncture	1 (< 1%)	0	1.00
Failed venous access	12 (5%)	8 (7%)	0.69
Misplaced CVC tip	1 (< 1%)	0	1.00
Difficult feed*	4 (2%)	4 (3%)	0.53
Difficult access	11 (4%)	9 (7%)	0.33
Pneumothorax	2 (1%)	0	0.55
Haematoma	2 (1%)	1 (1%)	0.56

* Difficult feed refers to difficulty in feeding either the guide wire or the catheter itself after vessel cannulation.

Catheter selection varied between the two groups, although the differences were not significant. This reflected the availability of different catheters during the study period. The characteristics of the CVCs inserted in both groups also differed. The CNC inserted more first-generation antiseptic-coated CVCs than the AMS (63% v 50%; $P=0.01$), but less second-generation antiseptic-coated catheters (2% v 33%; $P<0.01$).¹⁴ The CNC also inserted more antibiotic-coated CVCs (18% v 3%; $P<0.01$), reflecting differences in catheter availability and hospital policy for the use of antibiotic-coated CVCs (Table 2).

Oncology and autoimmune disorders were the primary reasons for a CVC insertion (59% [AMS group] and 66% [CNC group]). Antibiotic administration was the next most common reason for CVC placement (30% [AMS group] and 22% [CNC group]). These two categories accounted for most CVC insertions in both groups (89% and 88%, respectively). The least common indication for CVC insertion was parenteral nutrition (2% in both groups).

Insertion sites differed between the two groups. Insertion sites in the AMS group were equally distributed between internal jugular and subclavian sites (51% and 48%, respectively), with a small proportion of femoral lines (2%). The CNC inserted a higher proportion of internal jugular CVCs than subclavian CVCs (66% v 34%) and no femoral

Table 4. Outcomes of central venous catheter (CVC) tip surveillance

	Clinician type		<i>P</i> [†]
	Anaesthetic medical staff*	Clinical nurse consultant*	
Routine CVC tip surveillance [‡] (<i>N</i> = 159)	103 (42%)	56 (58%)	
No tip growth	79 (77%)	51 (91%)	0.01
Tip growth	24 (23%)	5 (9%)	< 0.01
Clinically indicated CVC tip surveillance, [§] (<i>N</i> = 56)	46 (19%)	10 (8%)	< 0.01
No tip growth	20 (44%)	9 (90%)	0.04
Tip growth only	7 (15%)	0	0.33
BC growth only	3 (6%)	0	1.00
CRBSI	16 (35%)	1 (10%)	0.24
CRBSIs/1000 catheters	2.5	0.4	0.04
Catheter-related thrombosis	1 (< 1%)	0	1.00

BC = blood culture. CRBSI = catheter-related bloodstream infection.

* Figures are number (%), except where otherwise indicated.

† Continuous data analysis using *t*-test and categorical data analysis using Fisher's exact test. ‡ No blood culture. § Tip and blood culture.

catheters (Table 1). Sixty-two per cent of CVCs inserted were triple lumen catheters.

There were low complication rates for CVC insertion in both groups, with no significant difference between the groups: 79% of insertions performed by AMS and 78% of those performed by the CNC were uneventful ($P=0.91$) (Table 3). During the study period, two instances of pneumothorax were recorded in the AMS group and none in the CNC group. Two patients in the AMS group and one in the CNC group had haematomas. AMS failed to obtain access in 12 attempted procedures, compared with eight by the CNC ($P=0.69$). One catheter-related thrombosis was confirmed in the AMS group on routine follow-up.

The proportion of CVCs sent for microbiological investigation with no signs of infection were similar in the two groups (42% [AMS] v 58% [CNC]). AMS recorded a higher rate of colonised catheter tips from this routine surveillance than the CNC (23% v 9%; $P < 0.01$) (Table 4). The average time from insertion to an infectious event for both groups was 22 days (range, 6–69 days).

The proportion of CVC tips sent for microbial investigation for suspected infection (where the catheter could not be excluded as a source) was higher in the AMS group than the CNC group (19% v 8%; $P < 0.01$). Confirmed CRBSIs within this subset were also higher in the AMS group (35% [AMS] v 10% [CNC]), but the difference was not significant ($P=0.24$). The CRBSI rate between the two groups differed. The rate of confirmed catheter infections (as defined by CDC guidelines) was 2.5/1000 catheters in the AMS group compared with 0.4/1000 catheters for the CNC group ($P=0.04$) (Table 4).

One CRBSI (from a non-coated catheter) was identified in the CNC group. Sixteen CRBSIs were identified in the AMS group: one from a second-generation antiseptic-coated CVC, six from antibiotic-coated CVCs and nine from non-coated CVCs.

Discussion

Our results show that outcomes of insertion of CVCs between the two groups were similar, with approximately 80% of all catheter placements being uneventful. AMS failed to obtain access in 12 attempted procedures compared with eight by the CNC. The CNC also had a smaller proportion of multiple passes (4% v 7%), but the difference was not significant. Although our results compare favourably with those in the international literature,¹⁵ particularly for the CNC group, the small number of patients and the elective context for insertion may have contributed to this finding.

The difference in infection rates between the two groups is of note, and, although the study design prohibits attribu-

tion of causality, there are some interesting points for discussion. All CVCs inserted by both groups were elective (non-emergency) cases. Management of CVCs after insertion was not controlled for. Catheters were managed in accordance with hospital-wide policy, with no differentiation in CVC care between the two groups. As we were unable to collect information on CVCs that were removed but not sent for microbiological testing, we measured the comparative incidence per 1000 catheters rather than per 1000 catheter-days.

One possible explanation for the difference in infection rates between the two groups could be a more rigorous application of full-barrier precautions and sterile technique during catheter insertion by the CNC. Some authors have reported that attention to these precautions is lower among medical staff than among nursing staff.^{16–18} The higher proportion of antibiotic-coated catheters placed by the CNC may also have contributed to the result.^{19–21} Of a total of 23 instances of multiple passes in both groups, only one (in the AMS group) was implicated in a CRBSI.

Our study took place in a metropolitan teaching hospital that cares for patients with many specialty and subspecialty illnesses. As a consequence, there was heterogeneity in the indications for catheter placement in both operator groups. For both groups, the same designated section in the recovery room was used, similar equipment was used for CVC insertion, and the procedure was performed under the same organisational policies.

Our study was observational, and as it was based on a convenience sample, patient selection for both groups could not be controlled for. Thus, there may have been bias in either group in relation to patient selection. Despite this, patient age, catheter-days of use and indications for CVC insertion were very similar in both groups.

The lower number of subclavian approaches by the CNC could be attributed to site choice as a matter of caution and safety. It could also be that the patients seen by the CNC may have been assessed as being at risk of bleeding during catheter placement. These parameters were not recorded as part of the study data collection, but were assessed prior to insertion as routine clinical practice.

The outcomes of nurse-led CVC insertion in this evaluation require consideration of wider implementation and further outcome review. Implementing and managing such a service requires a specialised set of skills, developed by training and mentoring within an interdisciplinary context.^{9–11}

Conclusion

We have shown that central venous catheter insertion by a clinical nurse consultant is a viable clinical option in both inpatient and outpatient settings. Nurse-led CVC placement

was equal to placement by anaesthetic medical staff with respect to the level of complications, and as such, has potential organisational advantages. Lower rates of CRBSIs/1000 catheters were found in the CNC insertion group, suggesting that a dedicated person with a critical care nursing background is suitable for this role and may help to improve standards.

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CENTRAL VENOUS CATHETER DATA FORM

1: Insertion Date: _____ Name & Classification of Inserting Practitioner: _____

- Area: ITU Recovery Anaesthetics ACCA Other: _____
- Indication for CVC: Patient diagnosis: _____

<input type="checkbox"/> Long term access	<input type="checkbox"/> Pressure monitoring
<input type="checkbox"/> No peripheral access	<input type="checkbox"/> Parenteral nutrition
<input type="checkbox"/> Drug administration	<input type="checkbox"/> Resuscitation
<input type="checkbox"/> Haemodialysis	<input type="checkbox"/> Line change
<input type="checkbox"/> Other: _____	
- Type of device: Single lumen/ impregnated Single lumen PICC
 Triple lumen/ impregnated Dual lumen PICC
 Other: _____ Vas Cath
- Specify product brand name: _____
- Type of solution used during insertion: Povidone-iodine Chlorhexidine/ Alcohol
- Insertion details: 1-3 passes Multiple passes/ sites Other: _____
- Insertion site: Subclavian Jugular Femoral Peripheral {L / R} Arm Circumference (cms) _____
- Insertion-related complications (please specify): _____

2: Maintenance * Please Complete Daily * IV Maintained by: IV Team _____ Ward _____

- Patient risk factors: Other invasive devices ~ specify Immune suppression Other: _____

Insertion Site and Dressing Description:*

Each small box represents one day. Enter appropriate date & code number(s).

- 1 = No erythema, tenderness or discharge
- 2 = Tenderness at insertion site
- 3 = Erythema < 5mm in diameter
- 4 = Erythema > 5mm in diameter
- 5 = Discharge/ exudate
- 6 = Febrile >38.5, CVC most likely cause
- 7 = Febrile >38.5, other cause most likely
- 8 = Dressing dry and intact
- 9 = Dressing soiled/ lifting
- 10 = Dressing changed
- 11 = Catheter removed

eg 1/5/00	1,9,10		

* More than one response may apply

3: Removal Date: _____

* Please Document Reason for Removing Line *

- Reason for line removal: Treatment complete Blocked Catheter
 Suspected infection Routine change
 Accidental removal Other: _____
- Evidence for infection: Fever +ve tip culture
 Site inflammation +ve blood culture
 +ve insertion site swab
- Infecting organism: Staph epidermidis Staph aureus Candida Other: _____
- Concurrent antibiotic therapy: _____

When the CVC is removed, complete as much of this form as possible. See over for mailing details

CHAPTER SIX

Publication Title: Nurse-led central venous catheter insertion –procedural characteristics and outcomes of three intensive care based catheter placement services

This chapter provides further supporting evidence on nurse led central venous catheter insertion. This chapter reviews the procedural characteristics and outcomes of three nurse-led central venous catheter insertion services based in intensive care units in New South Wales, Australia. Consecutive CVCs inserted by advanced practice nurses working in three separate hospitals in New South Wales were recorded as part of a wider quality improvement project to reduce central line associated bacteraemia (CLAB).

This chapter introduces the article presented as an original reprint published in the *International Journal of Nursing Studies* (2012) Volume 49, Issue 2, pages 162 – 168. (Impact Factor 2.075)

Background:

Nurse-led central venous catheter placement is developing as an emerging specialty role. Many of the specialty roles described in the literature on nurses placing central venous catheters have developed in response to workforce shortages of trained medical staff (Fitzsimmons et al., 1997; Gamulka, Mendoza, & Connolly, 2005; Gopal, Fitzsimmons, & Lawrance, 2006; H. C. Hamilton, 2005). Previous published papers have shown similarities in procedural outcomes to the greater, predominantly medical literature (Comfere & Brown, 2007; Fitzsimmons, et al., 1997; H. Hamilton, 2004; H. Hamilton, O’Byrne, & Nicholai, 1995).

Nurse led central venous catheter placement has shown in some studies to be safe and reduce procedural complication (Yacopetti et al., 2010). This manuscript provides further scientific evidence to this emerging specialty as a safe alternative that can reduce adverse events and increase hospital efficiency.

Aim of the study:

The aim of this study was to review the characteristics and outcomes of three nurse-led central venous catheter insertion services based in intensive care units in New South Wales, Australia. The study used data from the Central Line Associated Bacteraemia project in New South Wales intensive care units which comprised the insertion records of four advanced practice nurses working in three separate hospitals in New South Wales.

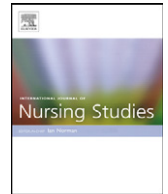
Brief results of the study:

Between March 2007 and June 2009, 760 vascular access devices were placed by three nurse-led central venous catheter placement services. Outcomes from these services were favourable with only 1 pneumothorax (1%), 1 arterial puncture (1%) and 1 CLAB (1%). The CLAB rate was lower in comparison to the aggregated CLAB data set [1.3 per 1000 catheters (95% CI = 0.03–7.3) vs. 7.2 per 1000 catheters (95% CI = 5.9–8.7)].

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Nurse-led central venous catheter insertion—Procedural characteristics and outcomes of three intensive care based catheter placement services

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ABSTRACT

Background: Nurse-led central venous catheter placement is an emerging clinical role internationally. Procedural characteristics and clinical outcomes is an important consideration in appraisal of such advanced nursing roles.

Objectives: To review characteristics and outcomes of three nurse-led central venous catheter insertion services based in intensive care units in New South Wales, Australia.

Design: Using data from the Central Line Associated Bacteraemia project in New South Wales intensive care units. Descriptive statistical techniques were used to ascertain comparison rates and proportions.

Participants: De-identified outcome data of patients who had a central venous catheter inserted as part of their therapy by one of the four advanced practice nurses working in three separate hospitals in New South Wales.

Results: Between March 2007 and June 2009, 760 vascular access devices were placed by the three nurse-led central venous catheter placement services. Hospital A inserted 520 catheters; Hospital C with 164; and Hospital B with 76. Over the study period, insertion outcomes were favourable with only 1 pneumothorax (1%), 1 arterial puncture (1%) and 1 CLAB (1%) being recorded across the three groups. The CLAB rate was lower in comparison to the aggregated CLAB data set [1.3 per 1000 catheters (95% CI = 0.03–7.3) vs. 7.2 per 1000 catheters (95% CI = 5.9–8.7)].

Conclusion: This study has demonstrated safe patient outcomes with nurse led CVC insertion as compared with published data. Nurses who are formally trained and credentialed to insert CVCs can improve organisational efficiencies. This study adds to emerging data that developing clinical roles that focus on skills, procedural volume and competency can be a viable option in health care facilities.

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What is already known about the topic?

- Evidence has shown that nurse led central venous catheter (CVC) placement has emerged in response to organisational need and shortages of skilled medical practitioners.
- Previous studies have concluded that insertion outcomes from nurse led CVC placement are similar to that of medical practitioner placements.

What this paper adds

- This study has contributed to emerging evidence that nurse-led CVC placement is safe and can reduce insertion complications.
- The results from this study have shown that dedicated nurse led CVC placement can potentially improve CVC associated infections through good insertion technique, diligent surveillance and staff education.

1. Introduction

Historically, central venous catheters (CVCs) have been inserted by medical practitioners. The technical complexity and potential procedural risk of complication has meant the responsibility for CVC placement has been traditionally the domain of medical practitioners (Comfere and Brown, 2007; Hamilton, 2005). The use of CVCs and peripherally inserted central catheters (PICCs) has increased in recent years due to their application in many acute and chronic care settings to provide venous access (Duerksen et al., 1999; Keckler et al., 2008). This increased demand and workforce shortages has led to the adoption of nurse-led models of care.

Improved patient outcomes for PICC and CVC insertion has been associated with the improved skills and increased competencies as a consequence of effective training and procedural volume (Alexandrou et al., 2010a; Yacopetti et al., 2010). Clinicians with minimal experience in inserting CVCs will have a higher risk of complications compared to those who have established procedural expertise (Comfere and Brown, 2007). This underscores the importance of procedural volume and demonstrated competency for achieving optimal patient and catheter related outcomes rather than which professional group performs the procedure.

Although it is accepted that the more often a procedure is undertaken by an individual, the greater their expertise will be, commonly there is a demarcation between professional roles and a vision as to what is “doctors” and “nurses’ work”. This professional divisiveness can prove to be counterproductive with missed opportunities to re-engineer processes to improve patient outcomes and achieve organisational efficiencies (Alexandrou et al., 2010a; Crowley, 2003; Dowling et al., 1995).

Increased health care specialisation and emerging technologies challenge the traditional approaches and scope of medical and nursing roles (Dowling et al., 1995). Emerging evidence suggests that increased specialisation and skill diversification amongst health professionals can increase the continuity and coordination of care resulting

in improved patient outcomes (Crowley, 2003; Dowling et al., 1995). Advanced practice nursing roles can be advantageous in providing a link for specialty clinical teams where medical staff increasingly have competing work demands and importantly, where there is a need for coordination (Cowan et al., 2006; Ritz et al., 2000).

These new nursing roles have often evolved on a pragmatic basis driven by such practicalities of shortage of medical practitioners (Dowling et al., 1995). It is important that when changes in clinical practice occur that the patient impact is carefully evaluated. There is now evidence that advanced practice nursing roles can provide improved patient safety and increased organisational efficiency (Yacopetti et al., 2010).

With statistical modelling in the US estimating a reduction of medical practitioners by up to 20% (approximately 200,000) by the year 2020 (Cooper et al., 2002), nurse-led CVC placement is emerging as a viable acute care role as a result of these shortages in experienced medical practitioners required to insert these devices (Alexandrou et al., 2010a). Patients have been placed at unacceptable risk for catheter insertion and infection because of the lack of supervision and training of junior medical staff (Alexandrou et al., 2010b). It has been identified that insertion complications from nurse-led CVC placement are within the acceptable limits of the published literature (Alexandrou et al., 2010a) and a reduction in waiting time for catheter placement has also shown to be an improvement to service delivery (Kelly, 2003; Waterhouse, 2002).

Nurse-led CVC insertion has been shown to work well in assisting and augmenting the medical services in providing catheter placement (Yacopetti et al., 2010). One study found no difference between medical and nursing CVC insertion outcomes where approximately 80% of all catheter insertions were uneventful. Infection outcomes from this same study showed that the catheter related blood stream infection (CRBSI) rate was 6.5 times less in the nurse group than those of the medical staff (Yacopetti et al., 2010).

A number of nurse led CVC insertion services exist in New South Wales (NSW), Australia. Four nurses based in intensive care that insert CVCs submitted data to a central database as part of an overarching bacteraemia reduction strategy. This provided a novel and unique opportunity to review the outcomes of CVC and PICC insertions performed by nurses. The aim of this study was to review the procedural characteristics and outcomes of the three nurse led CVC insertion services.

2. Methods

2.1. Design, data collection and participants

Central line associated bacteraemia (CLAB) have been implicated in contributing up to 60% of nosocomial acquired infections in intensive care patients (Pronovost et al., 2006). The NSW Central Line Associated Bacteraemia Intensive Care Units (CLAB-ICU) project was a successful ‘top down, bottom up’ initiative aimed at reducing the incidence of CLAB in NSW (Burrell et al., 2011). All adult

intensive care units (ICUs) in NSW and paediatric ICUs participated between March 2007 and June 2009. The project was coordinated by the NSW Clinical Excellence Commission (CEC).

The project promoted standard aseptic insertion technique to minimise the risk of CLABs. Insertion was targeted based on the premise that CLAB is caused by contamination at the time of insertion either from the patient's skin flora, or by the clinician inserting the central line (Fagin, 1992; Pronovost et al., 2006). The project was modelled on an international initiative promoting a clinical practice bundle to reduce infections using a collaborative methodology (Pronovost et al., 2006). Tools used to support change processes included a checklist, promotion of equipment co-location or sterile pack, monthly reporting, development of training materials and a framework to improve skill acquisition. The project resulted in the reduction of CLABS in NSW ICU patients by 60% by December 2008, a rate reduction of 3–1.2 CLABs/1000 patient line days, which has been sustained (Clinical Excellence Commission, 2010).

Ethical approval for this study was granted by a regional health service human ethics committee. De-identified data were retrieved from the original CLAB-ICU data set pertaining to the nurse led CVC insertion services from the CEC.

2.2. Setting

Hospital A is a large university affiliated teaching hospital with 650 beds. The hospital is in the south west of Sydney, Australia, with a 28-bed ICU and approximately 2000 admissions each year that also provides a Medical Emergency Team (MET) response (Lee et al., 1995). The hospital is a major trauma centre and has many specialty medical and surgical services.

The ICU supports the hospital with a nurse led elective CVC insertion service operational since 1996 and is staffed by a full time clinical nurse consultant and two part time clinical nurse specialists. The service also provides support to the general wards on the management of catheters and is also responsible for the management of parenteral nutrition for patients outside of the ICU.

Hospital B is a university affiliated metropolitan acute general hospital with 454 beds situated in the South West of Sydney, Australia. The hospital has a combined 14 bed ICU and high dependency unit (HDU) with approximately 1100 admissions per year.

The ICU/HDU is supported by a nurse practitioner (NP) who collaborates with the hospital medical teams to provide elective CVC, PICC and dialysis catheter insertion for in-patient and out patients outside of the ICU/HDU. The NP also supports the management of these catheters in the general wards and provides a liaison referral service for carers and patients who have been transferred from the ICU/HDU. The NP has provided the elective CVC placement service since 2006.

Hospital C is a university affiliated referral hospital with 420 beds situated in western Sydney, Australia. The hospital services include maternity, gynaecology, neonatal intensive care, emergency, diagnostics, paediatric, surgical,

intensive care, coronary care, cardiac catheter laboratory, rehabilitation and mental health.

The ICU consists of 13 ICU and 5 HDU beds. The annual admission rate is approximately 1200 patients. The ICU also provides several services to the wider hospital that includes a nurse led CVC insertion service that operates to provide catheter placement for in-patients and out patients outside of the ICU and has been operational since 1998.

All three services transfer patients to the ICU for monitoring and a controlled insertion environment for CVC placement. All nurses in the three services have undergone local hospital training and credentialing in the insertion of CVCs. The training methods although different between facilities, include the following components: theoretical tuition and assessment, observing senior clinicians inserting vascular access devices (VADs), supervised insertion and credentialing. All catheters inserted by the nurses were non tunnelled, uncuffed and percutaneously inserted. All patients described in this study were greater than 14 years of age.

2.3. Statistical analysis

Data received from the CEC was loaded into the statistical software package STATA Version 7.0 (StataCorp, 2001). Descriptive statistics are presented as frequencies and proportions. Categorical data which included catheter type, catheter coating and insertion outcome were tabulated and differences analysed using the Pearson's chi square statistic and the Fisher's exact test. Confidence intervals were used to assess range with some variables and then to assess differences across the three hospital groups.

3. Results

Between March 2007 and June 2009, 760 vascular access devices (VADs) were placed by the three nurse led CVC insertion services, making up approximately 5% of the total VADs inserted in ICUs ($N = 15,575$) across the state. Hospital A had the highest number of catheter placements over the study period with 520 catheters inserted followed by Hospital C with 164 and Hospital B with 76. There was a difference in the types of catheters used between the three groups ($p < 0.001$), however PICCs were the most common catheters inserted across all three groups (Table 1). Hospital B predominantly inserted PICCs during the study period with this device making up 93% of all insertions [95% CI = (85–98%)]. Hospitals A and C had a similar proportion (50% and 46%) of PICCs that were inserted. Hospital A was the only service to insert midline catheters [$N = 21$ (4%)]. Hospitals A and B also had a small proportion (4 or 1% vs. 1 or 1%) of VADs that were inserted that were not CVCs (intravenous cannulas) that were recorded during the study.

Hospitals A and B inserted only a small proportion of high flow/dialysis catheters (10 or 2% vs. 1 or 1%). Hospital C placed 29 dialysis catheters during the study making up 18% of catheters inserted for that group (95% CI = 12–24%).

Table 1
Vascular Access Device Type.

	Hospital A N (%) (95% CI)	Hospital B N (%) (95% CI)	Hospital C N (%) (95% CI)
CVC	224 (43) (39–47%)	3 (4) (0.8–11%)	60 (37) (29–44%)
Dialysis catheter	10 (2) (0.9–4%)	1 (1) (0.03–7%)	29 (18) (12–24%)
PICC	261 (50) (46–55%)	71 (93) (85–98%)	75 (46) (38–54%)
Midline	21 (4) (3–6%)	0	0
Other VAD	4 (1) (0.2–2%)	1 (1) (0.03–7%)	0
Total = 760	520 (100)	76 (100)	164 (100)

Differences between hospital groups using chi square analysis: $p < 0.001$.

Table 2
Elective versus Landmark Placement.

	Hospital A N (%) (95% CI)	Hospital B N (%) (95% CI)	Hospital C N (%) (95% CI)
Elective landmark placement	399 (77) (73–80%)	5 (7) (2–15%)	145 (88) (83–93%)
Elective ultrasound placement	94 (18) (15–22%)	71 (93) (85–98%)	5(3) (1–7%)
Emergency blind placement	8 (1) (0.7–3%)	0	1 (1) (0.02–3%)
Emergency ultrasound placement	19 (4) (2–6%)	0	13 (8) (4–13%)
Total	520 (100)	76 (100)	164 (100)

Differences between hospital groups using Fishers exact test: $p < 0.001$.

Table 3

Department placed $p < 0.140$ (Fishers)	Hospital A N (%)	Hospital B N (%)	Hospital C N (%)
Intensive care	500 (96)	75 (99)	164 (100)
Emergency	2 (0.5)	0	0
Ward	1 (0.5)	0	0
Other	17 (3)	1 (1)	0
Total	520 (100)	76 (100)	164 (100)

Differences between hospital groups using Fishers exact test: $p < 0.140$.

Ultrasound guided vascular access also differed amongst the three groups ($p < 0.001$). Hospital B inserted 93% [$N = 71$, 95% CI = (85–98%)] of elective catheters under ultrasound guidance and 7% [$N = 5$, 95% CI = (2–15%)] using the traditional landmark technique (Table 2). Hospital B had no emergency catheter placements. Hospitals A and C had a higher proportion of elective landmark technique catheter placements (399 or 77% vs. 145 or 88%) as opposed to elective ultrasound placements (94 or 18% vs. 5 or 3%). Hospitals A and C also inserted catheters under ultrasound guidance as an emergency procedure with Hospital C [$N = 13$ (8%), 95%CI (4–13%)] having twice the proportion as Hospital A [$N = 19$ (4%), 95% CI = (2–6%)].

The most common setting for catheter placement was the ICU for all three services (Table 3). Hospital A had a small proportion of catheters placed outside of the ICU such as the emergency department or outpatient setting

($N = 20$ or 4%). There was a difference between hospitals in relation to catheter coating preference ($p < 0.001$). Hospitals A and B inserted nearly all non coated catheters ($N = 513$ or 99% vs. $N = 76$ or 100%). Hospital C used a proportion of antiseptic coated catheters ($N = 34$ or 21%) and antibacterial catheters ($N = 3$ or 2%), see Table 4.

All three services had minimal insertion complications ($p < 0.01$). Hospital A recorded one pneumothorax (1%) during the study period and 1 catheter malposition (1%). Hospital C recorded a small proportion of catheter malpositions ($N = 7$ or 4%) and 1 arterial puncture (1%). There was only one CLAB during the study period attributed to Hospital C (1% or 6.1 per 1000 catheters for Hospital C). The nursing CLAB rate was low in comparison to the aggregated CLAB data set [1.3 per 1000 catheters (95% CI = 0.03–7.3) vs. 7.2 per 1000

Table 4

Catheter coating	Hospital A N (%)	Hospital B N (%)	Hospital C N (%)
Antibacterial coating	0	0	3 (2)
Antiseptic coating	7 (1)	0	34 (21)
Nil coating	513 (99)	76 (100)	127 (77)
Total	520 (100)	76 (100)	164 (100)

Differences between hospital groups using Fishers exact test: $p < 0.001$.

Table 5

Catheter Insertion Outcomes.

	Hospital A N (%)	Hospital B N (%)	Hospital C N (%)
Insertion outcome			
Malposition	1 (1)	0	4 (2)
Pneumothorax	1 (1)	0	0
Arterial puncture	0	0	1 (1)
Difficult guidewire feed	0	0	1 (1)
Failed access	0	0	1 (1)
Tip pulled back (in atrium)	0	0	2 (1)
Nil	518 (98)	76 (100)	155 (94)
Total	520 (100)	76 (100)	164 (100)
Infection outcome			
CLAB	0	0	1 (1)
Nil	520 (100)	76 (100)	163(99)
Total	520 (100)	76 (100)	164 (100)

Differences between hospital groups using Fishers exact test: $p < 0.01$.

Table 6

Site of Catheter Placement.

	Hospital A N (%) (95% CI)	Hospital B N (%) (95% CI)	Hospital C N (%) (95% CI)
Internal jugular	8 (1) (0.3–2%)	3 (4) (0.8–11%)	14 (8) (5–14%)
Subclavian	216 (42) (37–46%)	0	55 (34) (26–41%)
Femoral	11 (2) (1–4%)	1 (1) (0.03–7%)	20 (12) (8–18%)
Upper peripheral	285 (55) (50–59%)	72 (95) (87–99%)	75 (46) (38–54%)
Total	520 (100)	76 (100)	164 (100)

Differences between hospital groups using Fishers exact test: $p < 0.001$.

catheters (95% CI = 5.9–8.7)]. Hospital C also recorded 1 occasion of failed vascular access (1%).

These data showed that all three services had 100% compliance with full aseptic technique during the procedure. This technique included the use of an antimicrobial solution (between 1% and 2% chlorhexidine in 70% alcohol), use of full sterile draping, sterile gloves and gown along with cap and surgical mask. The compliance rate was attained from the standardised CLAB-ICU data collection and checklist form that was completed during and after the procedure either by an assistant or an observer (See online Appendix A). The compliance rate from the total CLAB-ICU data was 92%.

Catheter placement site also differed amongst the group ($p < 0.001$). Hospital A had a higher proportion of subclavian [$N = 216$ (42%), 95% CI = (37–46%)] and upper peripheral approaches [$N = 285$ (55%), 95% CI = (50–59%)]

for catheter placement. Hospital C used the highest number of femoral [$N = 20$ (12%), 95% CI = (8–18%)] and internal jugular approaches [$N = 14$ (8%), 95% CI = (5–14%)] amongst the three groups. Hospital B predominantly used the upper peripheral approach [$N = 72$ (95%), 95% CI = (87–99%)] for catheter placement. The proportion of femoral vein approaches were higher in Hospital A [$N = 11$ (2%), 95% CI = (1–4%)] than Hospital B ($N = 1$ or 1%) but the proportion of internal jugular approaches was higher in Hospital B than Hospital A ($N = 8$ or 1% vs. $N = 3$ or 4%) despite the relative small number of total catheters placed in comparison (Tables 5 and 6).

4. Discussion

This study was undertaken from a quality improvement project reviewing the incidence of CLABs in ICUs across

NSW Australia. Three nurse led services contributed to this data set. The review showed that all three services inserted a variety of VADs to service hospital ward populations and outpatients. Almost all catheters were inserted in the ICU and there were minimal insertion complications during the study period.

We found a difference in the application of ultrasound guided catheter placement between the hospital groups. Hospital B used ultrasound guidance more readily. A possible explanation could be that this mode of technology was more accessible in the ICU at the time of catheter placement or that it was a core component during the training and credentialing process for the nurse. Clinician preference may have also contributed to the use of ultrasound for catheter placement. All nurses preferred the landmark technique for the insertion of CVCs in the subclavian vein.

Hospital A was the only cohort to place midline catheters. This VAD has been used readily in the United States (Alexandrou et al., 2011) but is not as prominent in ICUs in Australia. It is possible that Hospital A has more familiarity with this VAD or that it was more readily available during the study period.

The use of different coated catheters between the three groups illustrated operator preference and availability of different catheters during the study period. One possible explanation could be that the operators in Hospitals A and C used coated catheters predominantly for patients at higher risk of infection such as critically ill or oncology patients.

Hospitals A and C predominantly used the subclavian approach or the upper peripheries for catheter placement with hospital B the upper peripheries. Catheters inserted by all nurses were mainly elective and for therapy which included antibiotic administration, parenteral nutrition, chemotherapy and long term vascular access. The subclavian route and upper peripheral veins for PICC lines were favoured as the potential for infection and other complications is less over time than using the jugular vein or femoral vein (McGee and Gould, 2003; O'Grady et al., 2002). However it was vascular assessment and therapy required that informed clinician preference for insertion site and VAD.

A significant proportion of catheters were inserted with minimal complications across all three groups with only one pneumothorax noted and one arterial puncture. Catheter tip malposition was noted in both hospital A and Hospital C, this result (although minimal) reflects the nature of catheter placement without the aid of fluoroscopic guidance (Ragasa et al., 1989). Across all three services almost all catheters were inserted in the ICU. However Hospital A inserted a small proportion in the emergency department and ward setting. This could be due to the unavailability of an ICU bed space at the time or the patients infectious status precluded them being transferred to the ICU for risk of cross contamination with ICU patients.

There was one CLAB noted across the three nurse groups (1% or 1.3 per 1000 catheters). This small catheter infection rate could be due to all three services having strict adherence to strict infection control and aseptic

technique during catheter insertion along with dedicated support to the general wards on the management of CVCs. Another explanation could be that most catheters in the total CLAB data set were emergency insertions and patients were most likely more complex and acutely ill. This difference in patient complexity, acuity and potential immunosuppression (which is inherent in ICU patients) could have contributed to the difference in CLAB rate.

The high infection control compliance rate with the nurses may be seen a strength and or a limitation in our study. It has been shown in many field experiments, that participants change their behaviour with the knowledge they are being observed (Hawthorne effect) (Adair, 1984) and as such may not be truly indicative of actual behaviour.

The initial CLAB ICU project was aimed at reducing CLAB in ICU, as a quality project it utilised convenient sampling and consecutive catheter placement was recorded with no randomisation. Inferences made from these results may potentially contain bias and other confounders including measurement error.

All three nurse-led services transferred ward patients and outpatients to the ICU for CVC insertion. The follow up of these patients post catheter insertion may not have been as vigorous as for the patients in intensive care. For this reason, the CLAB rate is presented per 1000 catheters instead of catheter days as some of the catheter removal dates were unable to be collected.

Using an administrative data set has inherent bias and confounders that may influence study results, as such no definitive inferences are made about the results. The authors also acknowledge that the rigor of administrative data sets depend on the accuracy, motivation and resources of individual teams. Therefore this data set may not reflect the total number of CVC insertions in this period by either nursing or medical staff.

5. Conclusion

In this study, nurse led CVC placement had minimal insertion complication and infection. Credentialed nursing staff in central venous catheterisation can potentially offer organisational efficiencies through early catheter placement and improved patient safety. In order to gain better evidence as to the impact of nurse led central venous access, further higher level research should be undertaken reviewing procedural characteristics and outcomes through international collaboration. However, this study adds to the emerging evidence that the synergy between medical and nursing roles or the development of new roles focusing on skills and competency rather than profession can deliver beneficial patient outcomes.

Author contributions

Evan Alexandrou, Margherita Murgo, Eda Calabria and Timothy Spencer planned and conducted the study, Steven Frost and Patricia Davidson assisted with data collation and analysis. Hailey Carpen, Kathleen Brennan and Ken Hillman had an active role in data interpretation. All authors then had an active role in contributing to the final manuscript.

Conflict of interest. None.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at doi:[10.1016/j.ijnurstu.2011.08.011](https://doi.org/10.1016/j.ijnurstu.2011.08.011).

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CHAPTER SEVEN

Publication Title: Central venous catheter placement by advanced practice nurses demonstrates low procedural complication and infection rates – A report from 13 years' service.

This is the final chapter submitted as a publication and provides a comprehensive review of a nurse led central venous catheter insertion service. This chapter reviews the procedural and infection outcomes from a hospital wide central venous catheter placement service operated by specialist nursing staff over 13 years. This report demonstrates safe insertion outcomes and low infection rates where 4560 catheters were placed in 3447 patients.

This chapter introduces the article presented as an original reprint published in *Critical Care Medicine* (2014) Volume 42, Issue 2, pages 536-543. (Impact Factor 6.124).

Background:

Although intravascular infections related to central venous catheters have been successfully reduced and prevented in a number of studies, these have been reported in specialised and confined settings such as intensive care units. Minimal data has been available to date on the success of the reduction or elimination of central line associated bacteraemia across a whole hospital (Burrell et al., 2011; Lombardo et al.; P. Pronovost et al., 2006; P. J. Pronovost et al., 2010; Son et al., 2012).

There have been a number of studies that have linked procedural skill success with procedural volume. A positive correlation exists between the number of procedures undertaken by a clinician and the successful outcome of that procedure (Hannan, O'Donnell, Kilburn Jr, Bernard, & Yazici, 1989; Schrag et al., 2006). There is emerging evidence that increased procedural load with central venous catheter insertion will improve success and reduce complications such as pneumothorax, accidental arterial puncture and intravascular infection (Guembe et al., 2012; Ong et al., 2011; Taylor & Palagiri, 2007).

This manuscript is an exemplar of the concepts mentioned above, where good training and procedural volume in central venous catheter placement are the predictor of low complication rates and reduce intravascular infection rather than clinician grade.

Aim of the study:

The aim of this study was to report on the characteristics and procedural outcomes from a hospital wide central venous catheter placement service operated by intensive care nursing staff over 13 years.

Brief results of the study:

Four thousand, five hundred and sixty catheters were placed in 3447 patients. The main indication for catheter placement was for antibiotic therapy (N= 2788; 61.1%) and single lumen peripherally inserted central catheters (N=1653; 36.3%) were the most frequent catheters inserted. Average device dwell time was 14 days with a cumulative 63071 catheter days. The overall catheter related blood stream infection rate was 0.2 per 1000 catheter days. Incidence rate of pneumothorax was 0.4% using the subclavian vein.

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Central Venous Catheter Placement by Advanced Practice Nurses Demonstrates Low Procedural Complication and Infection Rates—A Report From 13 Years of Service*

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Objectives: To report procedural characteristics and outcomes from a central venous catheter placement service operated by advanced practice nurses.

Design: Single-center observational study.

Setting: A tertiary care university hospital in Sydney, Australia.

Patients: Adult patients from the general wards and from critical care areas receiving a central venous catheter, peripherally inserted central catheter, high-flow dialysis catheter, or midline catheter for parenteral therapy between November 1996 and December 2009.

Interventions: None.

Measurements and Main Results: Prevalence rates by indication, site, and catheter type were assessed. Nonparametric tests were used to calculate differences in outcomes for categorical

data. Catheter infection rates were determined per 1,000 catheter days after derivation of the denominator. A total of 4,560 catheters were placed in 3,447 patients. The most common catheters inserted were single-lumen peripherally inserted central catheters ($n = 1,653$; 36.3%) and single-lumen central venous catheters ($n = 1,233$; 27.0%). A small proportion of high-flow dialysis catheters were also inserted over the reporting period ($n = 150$; 3.5%). Sixty-one percent of all catheters placed were for antibiotic administration. The median device dwell time (in d) differed across cannulation sites ($p < 0.001$). Subclavian catheter placement had the longest dwell time with a median of 16 days (interquartile range, 8–26 d). Overall catheter dwell was reported at a cumulative 63,071 catheter days. The overall catheter-related bloodstream infection rate was 0.2 per 1,000 catheter days. The prevalence rate of pneumothorax recorded was 0.4%, and accidental arterial puncture (simple puncture—with no dilation or cannulation) was 1.3% using the subclavian vein.

Conclusions: This report has demonstrated low complication rates for a hospital-wide service delivered by advance practice nurses. The results suggest that a centrally based service with specifically trained operators can be beneficial by potentially improving patient safety and promoting organizational efficiencies. (*Crit Care Med* 2014; 42:536–543)

Key Words: bacteremia; catheter-related infections; catheterization; central venous catheter; clinical nurse specialist; peripheral catheterization

***See also p. 731.**

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Over 5 million central venous catheters (CVCs) are inserted each year in hospitalized patients in North America (1). Essential for many therapies, they are associated with adverse events contributing to patient morbidity and mortality (1, 2). Foremost of these adverse events is catheter-related bloodstream infection (CRBSI). Each year an estimated 250,000 potentially preventable bacteremia attributable to intravascular catheters occur in the U.S. hospitals, resulting in a cost of 2.3 billion U.S. dollars to the healthcare system and 31,000 deaths annually (1–4).

Prevention of CRBSI has been successfully demonstrated when predetermined care bundles are implemented during CVC insertion and routine care (1–5). The success of such prevention strategies in specialized and confined settings such as ICUs has prompted the U.S. Department of Health and Human Services to target a 50% reduction in intravascular bacteremia in general ward areas as one of its key 5-year national prevention objectives (6, 7). Currently, there are limited data on the success of care bundles in a general ward environment compared with specialized areas such as ICUs.

Poor insertion technique and a lack of operator experience can lead to procedural complications such as pneumothorax, accidental arterial puncture, and catheter malposition (4, 7–10). Several investigators have identified clinician procedural volume as an important predictor of reduced adverse events (11–15). Similarly, increased experience with CVC placement has shown to improve both catheter- and patient-related outcomes (16, 18).

Operator experience is not always synonymous with professional qualification, and there have been some documented benefits regarding nurse-led CVC placement. In particular, nurse-led CVC placement has shown improvement in organizational efficiency through earlier catheter placement and patient follow-up along with regular surveillance and consultation to clinicians on appropriateness of device selection, maintenance, and removal (19–21). Despite existing studies published on the effectiveness of nurses inserting CVCs and peripherally inserted central catheters (PICCs) (collectively referred to as “central venous access devices” [CVADs]), the paucity of large sample investigations with scientific rigor warrants this model to be further investigated.

This study reports the characteristics and outcomes of patients from the general ward areas who had CVAD placement by a centralized service managed through the ICU and delivered by three advanced practice nurses (APNs) over a 13-year period.

MATERIALS AND METHODS

Data Source and Study Population

The study setting is an 850-bed, tertiary care university hospital situated in Sydney, Australia. A CVAD placement service operating within the ICU provides elective catheter placement for patients on the general wards of the hospital and occasionally for patients in critical care areas. The service was established in December 1996 when the hospital underwent significant redevelopment, which impacted greatly on the workload of the ICU. Competing work demands for the ICU physicians affected their ability to provide a timely and efficient CVAD placement service for non-emergent (general ward) patients. Because of fiscal restraints with employing more ICU medical trainees, the ICU physicians used in-house resources and trained a senior ICU nurse to undertake some duties to relieve medical staff workload (19).

The service currently operates with three APNs who are certified clinical nurse specialists in intensive care nursing. The APNs have undertaken further hospital-based training to be credentialed in CVAD placement. Training involved theoretical and practical assessment including 20 supervised catheter insertions

for each anatomical site (internal jugular, femoral, subclavian, and brachial veins). The APNs have also been formally trained in ultrasound guidance for CVAD placement since 2006.

With executive support from medicine and nursing, the CVAD service is operated exclusively by the APNs who are responsible for inserting the catheters, providing follow-up clinical support, and organizing hospital-wide educational activities. The service is also responsible for assisting in the training of ICU medical trainees in central venous cannulation.

Device and vessel selection is based on the duration of parenteral treatment, number of catheter lumens required, and patient assessment. The funding model for the service is shared between the ICU and the general wards of the hospital. The ICU is responsible for funding the nursing positions (currently 1.2 full-time equivalent) while the clinical wards reimburse the ICU for all consumables.

All patients receiving a vascular access device through the service are entered into an administrative database that has been operating since service inception. Data were extracted and loaded into statistical software (STATA Version 7, StataCorp LP, College Station, TX) for analysis.

Ethical approval for this study was granted by the regional health service human ethics committee. Report cases are categorized in accordance with the four divisional streams of the hospital—medical, surgical, critical care, and women and child health.

Outcome Measures

Outcomes of interest were based on CVADs placed in adult patients between November 1996 and December 2009 and included 1) patient and device characteristics; 2) procedural complications; and 3) prevalence of CRBSI. The authors used the Centres for Disease Control and Prevention definitions for laboratory-confirmed CRBSI (22, 23).

Statistical Analysis

Details of patient demographics and prevalence rates for indication of catheter insertion, site of insertion, and type of catheter are documented. Differences in each categorical variable were assessed using the chi-square test; in instances where the assumptions for chi-square tests were violated, the Fisher exact test was used. The median dwell time (in d) was calculated for each insertion site along with their interquartile ranges (IQRs); the Kruskal-Wallis test was then used for comparing a continuous variable against a categorical variable to calculate any differences between median catheter dwell times for each site.

The prevalence rates of CRBSIs per 1,000 catheter days were calculated for each insertion site and clinical division after clinical record review for derivation of denominator. Date of hospital discharge was documented as the date of catheter removal for those patients who were discharged with catheter still in place.

RESULTS

Patient Characteristics

Between November 1996 and December 2009, a total of 4,560 catheters were placed by the service in 3,447 patients (Table 1).

TABLE 1. General Patient and Catheter Characteristics

Characteristics	Clinical Division				Total	p
	Medical	Surgical	Women and Child Health	Critical Care		
Mean age (SD)	56 (18)	56 (18)	35 (15)	53 (20)	56 (18)	0.262
Female gender (%)	867 (47.6)	601 (38.4)	27 (71.1)	3 (15.9)	1,498 (43.5)	0.05
Number of patients (%)	1,822 (52.9)	1,567 (45.5)	38 (1.1)	19 (0.5)	3,447 (100)	< 0.001
Number of catheters (%)	2,528 (55.4)	1,969 (43.2)	43 (0.9)	20 (0.4)	4,560 (100)	< 0.001
Primary indication for catheter (%)						
Antibiotics	1,267 (50.1)	1,482 (75.3)	31 (72.1)	8 (40.0)	2,788 (61.1)	< 0.001
Chemotherapy/stem cell treatment	770 (30.5)	8 (0.4)	1 (2.3)	0	781 (17.1)	< 0.001
Poor vascular access	176 (7.0)	160 (8.1)	4 (9.3)	3 (15.0)	343 (7.5)	< 0.001
Parenteral nutrition	34 (1.3)	198 (10.1)	2 (4.7)	1 (5.0)	235 (5.2)	< 0.001
Other indications	84 (3.3)	89 (4.5)	5 (11.6)	5 (25.0)	183 (4.0)	< 0.001
Other parenteral medication	107 (4.2)	22 (1.1)	0	3 (15.0)	132 (2.9)	< 0.001
Hemodialysis/plasmapheresis	92 (3.6)	8 (0.4)	0	0	100 (2.2)	< 0.001
Catheter type (%)						
Standard single-lumen CVC	546 (21.6)	675 (34.3)	11 (25.6)	1 (5.0)	1,233 (27.0)	< 0.001
Standard double-lumen CVC	198 (7.8)	146 (7.4)	2 (4.7)	0	346 (7.6)	< 0.001
Standard triple-lumen CVC	618 (24.4)	161 (8.2)	7 (16.3)	4 (20.0)	790 (17.3)	< 0.001
Antiseptic single-lumen CVC	24 (0.9)	30 (1.5)	0	1 (5.0)	55 (1.2)	< 0.001
Antiseptic triple-lumen CVC	65 (2.6)	7 (0.4)	0	2 (10.0)	74 (1.6)	< 0.001
Single-lumen PICC	785 (31.1)	841 (42.7)	19 (44.2)	8 (40.0)	1,653 (36.3)	< 0.001
Double-lumen PICC	89 (3.5)	61 (3.1)	0	4 (20.0)	154 (3.4)	< 0.001
Midline	52 (2.1)	41 (2.1)	4 (9.3)	0	97 (2.1)	< 0.001
Vascath	150 (5.9)	8 (0.4)	0	0	158 (3.5)	< 0.001

CVC = central venous catheter, PICC = peripherally inserted central catheter.

Other indications include physician request for catheter, catheter change, and preoperative catheter placement; other parenteral medications refer to catheter placement for specific drug therapy other than antibiotics.

This amounted to a total of 63,071 catheter days. Seventy-five percent of patients had one occasion of catheter placement. Some patients received more than one episode of catheter insertion due to therapy requirements with the uppermost being seven occasions. The medical division had the highest number of catheters ($n = 2,528$; 55.4%) placed followed by the surgical division with 1,969 catheters (43.3%). The lowest number of catheter placements by the centralized service was for the critical care division ($n = 20$; 0.4%). Specialized areas such as intensive care, emergency rooms, and operating rooms commonly insert their own catheters.

Gender distribution differed across the clinical categories; more males had catheters inserted than females (56.5% vs 43.5%, $p = 0.05$). This was the case across the clinical divisions except, of course, for the division of women and child health (incorporating obstetrics and maternity). When we reanalyzed gender distribution without the division of women and child health to assess any influence of this division on the

overall distribution, we found a significant difference in the distribution of males and females in the other three divisions ($p < 0.001$). The mean age across all cases was 56 years (SD, 18 yr).

Catheter Characteristics

In 61% of all cases ($n = 2,788$), antibiotic administration was the primary reason for catheter insertion. Surgical patients received the most catheter placements for antibiotic therapy ($n = 1,482$); proportionately, this was 75% of all catheters inserted for this division. Nearly all patients receiving catheter placement for chemotherapy or stem cell transplant were represented in the medical division ($n = 770$; 98.6% of all catheters). The divisions of medicine and surgery had similar numbers of patients who received catheter placement as a result of poor peripheral vascular access ($n = 176$ vs $n = 160$) (Table 1).

There was a difference among the distribution of catheter placement across the four divisions ($p < 0.001$). The most common of devices inserted overall were standard (uncoated)

single-lumen PICCs ($n = 1,653$; 36.3%) followed by standard single-lumen CVCs ($n = 1,233$; 27.0%). Standard triple-lumen CVCs comprised 17.3% of catheters inserted ($n = 790$). A small number of antiseptic-coated single-lumen CVCs ($n = 55$; 1.2%) and triple-lumen CVCs ($n = 74$; 1.6%) were also inserted (Table 1). The service likewise inserted a small proportion of high-flow dialysis catheters ($n = 158$; 3.5%) and (although not a CVAD) a small number of midline catheters ($n = 97$; 2.1%).

Procedural Outcomes

There was minimal difference in total procedural complications between the central venous cannulation sites (internal jugular, subclavian, and femoral veins). Approximately 92% of all central venous cannulations reported over the 13 years were uneventful. A difference was found with only inadvertent arterial puncture (simple puncture—with no dilation or cannulation, $p = 0.01$). The femoral approach had the highest proportion ($n = 7$; 4.3%) of simple arterial puncture; this is despite the highest number reported were from the subclavian approach ($n = 30$; 1.3%), thus reflecting the large denominator and favored choice of this vessel (Table 2 and Fig. 1).

There were a total of nine pneumothoraces reported over the 13-year period (0.4%), and all were attributed to the subclavian approach. No pneumothoraces occurred using the internal jugular approach. The median dwell time (in d) differed across the three central venous cannulation sites ($p < 0.001$), with subclavian catheters having the longest median dwell time of 16 days (IQR, 8–26 d) (Table 2).

In comparison, a difference was found across peripheral cannulation sites (basilic, antecubital, and cephalic veins; $p < 0.001$). Just over 69% of all peripheral cannulations were uneventful over the 13 years of service. The cephalic vein approach had the lowest success rate with 162 of the 377 catheters (43%) being placed without impediment. The success rates for the antecubital and basilic vein approaches were higher (75.4% vs 79.5%, $p < 0.001$) (Table 2 and Fig. 2). Ninety-one cephalic approaches (24.1%) were reported to have difficulty in feeding the PICC through the vessel. This culminated in 42 catheter tips (11.1%) terminating in the axillary/subclavian vein (presented in Table 2 and Fig. 2 as midclavicle catheter tip termination).

A difference was also found in the median dwell time between the peripheral insertion groups ($p < 0.001$) with the basilic vein approach having the longest median dwell time of 12 days (IQR, 3–23 d). The range was also spread with the antecubital approach (median, 10 d; IQR, 4–26 d) and cephalic approach (median, 10 d; IQR, 3–20 d) (Table 2).

Since the implementation of ultrasound guidance into daily procedural practice for catheter insertion (in 2006), the service has observed a small reduction in procedural complication rates with central venous cannulation sites, as the complication rates for these sites were already low; no statistical difference was found (Table 3).

A reduction was also found in procedural complication rates with peripheral cannulation insertions. We observed a reduction in catheter malposition rates for the basilic vein

approach (8.7% vs 1.7%, $p < 0.001$) and also the cephalic vein approach (8.0% vs 0.25%, $p < 0.001$). We also observed a reduction in failed vascular access rates (11.4% vs 1.6%, $p < 0.001$) and difficult feed of catheter rates (23.6% vs 0.5%, $p < 0.001$) with the cephalic vein. Table 3 illustrates a breakdown of procedural complication rates for CVADs pre and post ultrasound guidance.

Prevalence of CRBSI

There were no differences in diagnosed CRBSI rates between the central venous cannulation sites ($p = 0.33$) with a total of 12 intravascular infections reported. The subclavian approach had the highest number with 10 CRBSIs (0.3 per 1,000 catheter days). Interestingly, this vessel also had the highest median dwell time. The femoral approach had the highest rate of CRBSI ($n = 1$, 0.8 per 1,000 catheter days). One CRBSI was also reported with the internal jugular approach (0.1 per 1,000 catheter days).

Similarly, there were no differences in diagnosed CRBSI rates between peripheral cannulation sites ($p = 0.27$). There was one intravascular infection that was reported with a cephalic vein approach (0.25 per 1,000 catheter days).

Overall, there were 13 diagnosed CRBSIs across all clinical divisions; surgical patients had the highest number with nine occasions. The overall CRBSI rate reported by the service was 0.2 per 1,000 catheter days.

DISCUSSION

Over a 13-year period, a dedicated, hospital-wide service has demonstrated insertion of 4,560 catheters, with a pneumothorax rate of 0.4% and simple arterial puncture rate of 1.3% using the subclavian vein. Complication rates for CVCs meet or exceed previously published international standards (16, 24). Similarly, the overall CRBSI rate of 0.2 per 1,000 catheter days meets or exceeds previous rates. A recent study found the CRBSI rate across 10 U.S. hospitals to range between 0.2 and 4.2 per 1,000 catheter days in patients from the general wards (25). Other studies have reported hospital-wide catheter-related bacteremia rates at up to 12.2 per 1,000 catheter days (6).

The low procedural complication rate in this series (compared with published rates) (16, 17) can potentially be explained by the level of training and credentialing required by the operators and the skills and competence achieved by high volume. Credentialing involved didactic learning with tutorials administered by senior ICU physicians. Written examination involved preinsertion assessment, intraprocedural complication management, and postinsertion assessment and management. Practical tuition included the nurses observing a number of catheter insertions prior to undertaking the skill (19). Procedural volume also played a role where nurses undertook 20 supervised catheter insertions for each anatomical site (internal jugular, subclavian, femoral, and brachial veins). The intensive care physicians supervised the credentialing of the APNs.

Operationally, the CVAD placement group (known as “The Central Venous Access Service”) functions within established hospital guidelines. All patients are required to have informed

TABLE 2. Total Catheter-Related Outcomes

Complications	Internal Jugular Vein	Subclavian Vein	Femoral Vein	p
	n = 93	n = 2,383	n = 163	
CVC-related complications				
No complications (%)	86 (92.4)	2,193 (92.0)	153 (93.9)	0.74
Arterial puncture (%)	2 (2.2)	30 (1.3)	7 (4.3)	0.01
Catheter tip malposition (%)	2 (2.2)	58 (2.4)	0	0.09
Difficult feed of catheter (%)	1 (1.0)	17 (0.7)	2 (1.2)	0.34
Failed vascular access (%)	2 (2.2)	49 (2.1)	2 (1.2)	0.81
Hemothorax (%)	0	1 (0.04)	0	1.00
Midclavicle catheter tip termination (%)	0	2 (0.1)	0	1.00
Other complications (%)	0	24 (1.0)	0	1.00
Pneumothorax (%)	0	9 (0.4)	0	1.00
Diagnosed CRBSI (per 1,000 catheter days)	1 (0.1)	10 (0.03)	1 (0.8)	0.33
Median dwell in days (IQR)	10 (5–17)	16 (8–26)	9 (3–11)	< 0.001
Complications	Basilic Vein	Antecubital Vein	Cephalic Vein	p
	n = 1,402	n = 142	n = 377	
PICC-related complications				
No complications (%)	1,057 (75.4)	113 (79.5)	162 (43.0)	< 0.001
Arterial puncture (%)	2 (0.1)	0	2 (0.5)	0.41
Catheter tip malposition (%)	146 (10.4)	3 (2.1)	31 (8.2)	0.001
Difficult feed of catheter (%)	91 (6.5)	14 (9.9)	91 (24.1)	< 0.001
Failed vascular access (%)	49 (3.5)	1 (0.7)	49 (13.0)	< 0.001
Midclavicle catheter tip termination (%)	57 (4.1)	11 (7.7)	42 (11.1)	< 0.001
Diagnosed CRBSI (per 1,000 catheter days)	0	0	1 (0.25)	0.27
Median dwell in days (IQR)	12 (3–23)	10 (4–26)	10 (3–20)	< 0.001

CVC = central venous catheter, CRBSI = catheter-related bloodstream infection, IQR = interquartile range, PICC = peripherally inserted central catheter. Other complications include hematoma and innominate vessel placement.

consent prior to the procedure; preassessment must include patient history, allergies, medications taken such as anticoagulants, and blood pathology results. In particular, coagulation variables for CVC placement to proceed include an activated partial thromboplastin time between 35 and 45 seconds, platelet count greater than $50,000 \times 10^9/L$, and an international normalized ratio no greater than 1.5 (19). If patients are anticoagulated, this is often corrected prior to catheter insertion but is dependent on patient status and urgency of catheter placement.

The CVAD insertion service described in this report employs an integrated, person-centered approach where catheter placement is only a single dimension. The service is involved in catheter surveillance and staff education, which includes maintenance of devices. Part of the role of the APNs is to assist in the training and supervision of ICU medical trainees in CVAD

placement. The service also provides consultancy to the general wards on care and management issues related to vascular access devices (19). Other CVAD insertion services involve the insertion of catheters by numerous individuals with varying levels of skill and competencies (26). A dedicated service using best practice recommendations may be efficacious in improving patient outcomes (19, 20).

One outlier for our procedural complications was catheter tip malposition and difficult feeding of PICCs, particularly with the use of the cephalic vein. This could be explained by the tortuous pathway of this upper peripheral vessel. The advent of ultrasound guidance has limited the need to use this vessel (26, 27). The service has observed a decrease in catheter malposition rates since the implementation of ultrasound guidance with the ability to use this technology in undertaking vessel assessment prior to catheter insertion and for intraprocedural scanning.

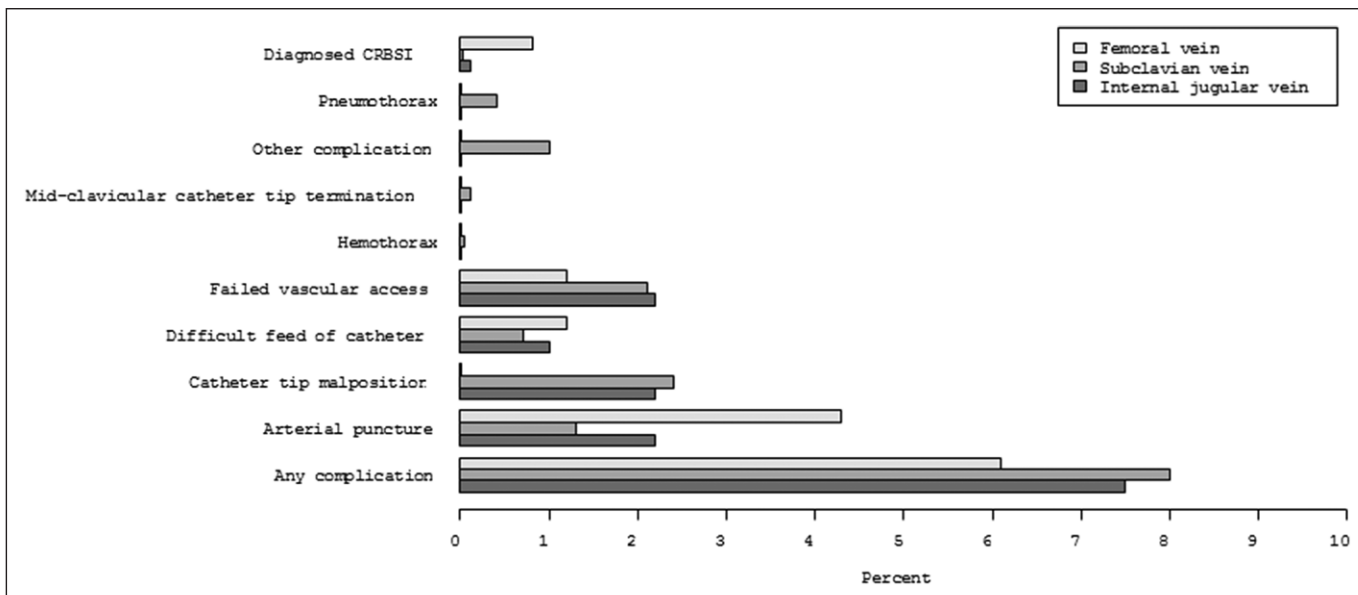


Figure 1. Rates of complications among central venous catheters inserted at the femoral, subclavian, and internal jugular sites. Rates of catheter-related bloodstream infection (CRBSI) are per 1,000 catheter days.

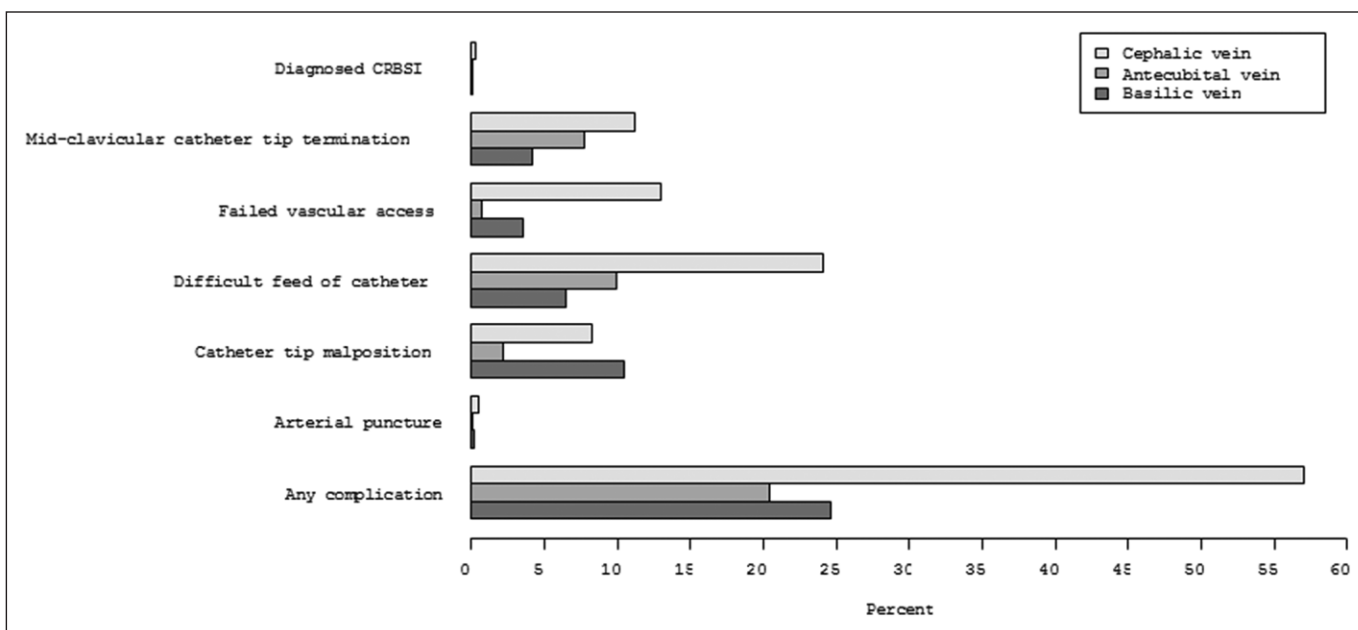


Figure 2. Rates of complications among peripherally inserted central venous catheters at the cephalic, antecubital, and basilic sites. Rates of catheter-related bloodstream infection (CRBSI) are per 1,000 catheter days.

Our catheter tip malposition rate can also be explained by the manner in which the service operates; it uses a bedside insertion model without the aid of fluoroscopic or electrocardiogram guidance. These technologies have been shown to significantly reduce the prevalence of catheter tip malposition and provide optimal tip placement (28, 29).

The results from our report should be interpreted in the context of a number of potential limitations. First, we report on CVAD placement by APNs from a single center where we did not undertake any comparison. Small studies have been undertaken

previously that have shown comparable outcomes between APNs and medical practitioners with CVC placement (20).

Another potential limitation to the findings of our study may be type I error. In particular, we have used multiple tests of significance and individual patients had multiple catheters inserted. Both these factors would increase the risk of type I error; however, we think that the overall interpretation of our results would be unchanged using more advanced statistical approaches to adjust for multiple tests (such as Bonferroni's correction) and to deal the repeated catheters among individuals.

TABLE 3. Breakdown of Catheter-Related Complications Pre and Post Ultrasound Utilization

Vessel Approach	Arterial Puncture	Catheter Tip Malposition	Difficult Feed of Catheter	Failed Vascular Access	Midclavicle Catheter Tip Termination
CVC-related complications					
Internal jugular vein (<i>n</i> = 93)					
Pre (%)	2 (2.2)	2 (2.2)	1 (1.1)	2 (2.2)	0
Post (%)	0	0	0	0	
<i>p</i>	0.5	0.5	1.0	0.5	
Femoral vein (<i>n</i> = 163)					
Pre (%)	5 (3.1)	0	2 (1.2)	2 (1.2)	0
Post (%)	2 (1.2)		0	0	
<i>p</i>	0.4		0.5	0.5	
PICC-related complications					
Basilic vein (<i>n</i> = 1,402)					
Pre (%)	1 (0.07)	122 (8.7)	65 (4.6)	31 (2.2)	50 (3.6)
Post (%)	1 (0.07)	24 (1.7)	26 (1.9)	18 (1.3)	7 (0.5)
<i>p</i>	1.0	< 0.001	< 0.001	0.08	< 0.001
Antecubital vein (<i>n</i> = 142)					
Pre (%)	0	2 (1.4)	14 (9.9)	1 (0.7)	10 (7.0)
Post (%)		1 (0.7)	0	0	1 (0.7)
<i>p</i>		1.0	1.0	1.0	0.01
Cephalic vein (<i>n</i> = 377)					
Pre (%)	2 (0.5)	30 (8.0)	89 (23.6)	43 (11.4)	41 (10.9)
Post (%)	0	1 (0.25)	2 (0.5)	6 (1.6)	1 (0.25)
<i>p</i>	0.49	< 0.001	< 0.001	< 0.001	< 0.001

CVC = central venous catheter, PICC = peripherally inserted central catheter.

The increased use of CVADs can impose pressures on medical teams in terms of the time needed to reach safe and proficient skill levels. Specialization and workload requirements have increased the dependence on a multidisciplinary approach to clinical care as it is increasingly difficult to maintain all the skills and knowledge necessary to manage all aspects of a patient’s illness (30). There have been a number of small studies supporting the role of nursing staff inserting CVADs as an organizational solution, resulting in increased efficiency, reduced cost, and improved clinical care (21, 31–33). Furthermore, increased procedural load has been shown to improve patient care in many specialty areas (11–15).

This report suggests that a dedicated hospital-wide catheter placement service can achieve procedural and infection rates across the hospital that are consistent with rates achieved by medical staff in specialized environments such as ICUs. The results indicate that a well-trained and dedicated service employing a high procedural volume can have beneficial patient- and device-related outcomes that are not

necessarily linked to the clinician’s professional background. Absence of randomized comparison data limits the capacity to determine causality. However, this large dataset of prospective, consecutive data provides some insight into a model of intervention that can potentially improve patient safety and quality of care.

CONCLUSIONS

This report reviewed outcomes of patients who had catheters inserted by a hospital-wide service operated by specialist nursing staff over a 13-year period. It reports on the insertion of 4,560 catheters with procedural and CRBSI complication rates equal to or better than those previously published. The results suggest that a centralized service with a small number of specifically trained personnel may be more important to procedural success than clinician grade.

The large sample reported on consecutive catheter placement by APNs with low procedural complication rates and

infection rates makes this report significant and of interest to intensivists and hospital administrators internationally.

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CHAPTER EIGHT

REVIEW AND DISCUSSION

This thesis has revealed a paucity of quality outcome data on the benefits of nurse-led CVAD insertion and has addressed the disparity of eminent research on this model of care. Prior to this program of research, there was minimal data on the genesis and implementation of nurse-led CVAD placement and its impact on patient care. Importantly, there was no rigorous data on the benefits of specialisation in vascular access by advanced practice nurses in influencing patient outcomes through device selection and safe and efficient insertion of vascular access devices. This work describes for the first time, procedural characteristics and outcomes of nurse-led CVAD insertion.

This thesis has justified nurse-led CVAD insertion as model of care to address the increasing requirement for CVADs. Central venous access devices are indispensable in modern-day health care. They are increasingly being used outside of the intensive care unit and operating theatres with a large proportion now being used on the general wards due to the acuity and complexity of patient illness (Arenas-Marquez, Anaya-Prado, Barrera-Zepeda, & Gonzalez-Ojeda, 2001; Polderman & Girbes, 2002). The increased use of vascular access devices has contributed to an increase in complications such as CRBSI / CLAB. This complication is associated with an increased length of hospital stay and carries an increased risk of mortality (Fridkin, Pear, Williamson, Galgiani, & Jarvis, 1996).

Nurse led Central Venous Catheter Placement – Improving Hospital Quality and Safety:

Preventing intravascular infections and insertion complications is becoming an important program of quality improvement for health care organisations. Reduction in CRBSI has been successfully demonstrated when predetermined care bundles are implemented during CVC insertion and routine care (Berenholtz et al., 2004; Ong et

al., 2011; Pronovost et al., 2006).

A poor insertion technique, or lack of procedural experience can contribute to complications such as pneumothorax, arterial puncture and intravascular infection (Berenholtz et al., 2004; Costello et al., 2008; Guembe et al., 2012; Price et al., 1999). These complications can increase the risk of life threatening sequelae, particularly in the acutely ill or patients with chronic conditions. Through the program of research undertaken in this thesis, it has been validated that specialist nurses inserting these devices can mitigate many of these risks.

Nurse-led central venous catheter placement and device management can improve quality of patient care and organisational efficiency by providing early catheter placement and reducing delay in treatment and therefore improving patient outcomes and satisfaction. The study in chapter two (*A review of the nursing role in central venous cannulation: implications for practice policy and research*) reviewed the best available literature on nurse-led central venous catheter (CVC) placement. The review illustrated that many of the nurse-led services were developed because of the need to improve organisational efficiencies and improve patient outcomes (Alexandrou et al., 2010b). This study illustrated that when this model of care was implemented, organisational efficiency gains were found through earlier catheter placement coinciding with minimal procedural complications. The review cited examples where waiting periods for dialysis catheter placement was decreased from 48 days to 2-5 days (Waterhouse, 2002) and in another, the improvement in efficiency increased to 97% of catheter requests being dealt with on the same day (Fitzsimmons et al., 1997). This review also found that procedural outcomes were similar to published procedural complication rates.

The third chapter in the thesis sought to identify the process of establishing a nurse-led CVC insertion service by reviewing an established service based in a teaching hospital in Sydney, Australia (*Establishing a Nurse-Led Central Venous Catheter*

Insertion Service) (Alexandrou et al., 2010a). The rationale for the implementation for this nurse-led model of care was driven by the motivation to improve hospital efficiency, reduce the delay in catheter placement and improve outcomes was identified (Alexandrou et al., 2010a).

The review of archival information identified four major themes from the data that identified barriers to service implementation: 1) opinions of some medical clinicians such as surgeons who were sceptical of a nurse inserting CVC's in their patients and would potentially put them at greater risk of procedural complication, 2) medico-legal concerns were raised regarding nurses undertaking traditional medical roles, 3) risk minimization strategies such as the need for senior medical staff to be available if required, and 4) negotiating funding models that would cover the cost of the nursing staff and consumables. This publication is a written account of how such barriers were dealt with and overcome. The major factor contributing to facilitating implementation of such a service was clinical leadership for the nurses that involved mentoring and education from senior medical staff. Such senior medical staff were also pivotal in influencing key stakeholders within the organisation. (Alexandrou et al., 2010a).

Optimal vascular access device and patient outcomes are not only determined by the procedural efficiency of the clinician but also their ability to assess patient requirement and insert the most appropriate device suited for the patient's therapy. Chapter Four (*The Use of Midline Catheters in the Adult Acute Care Setting – Clinical Implications and Recommendations for Practice*) provided an exemplar of specialist nurses using their expertise for vascular access device selection that takes into consideration the patients venous circulation, medical history along with the acidity and osmolarity of the infusate. When inserted and used appropriately, midline catheters were found to be favourable as they avoided unnecessary repeated peripheral cannulation. These devices were found to be cost effective and benefited hospital efficiency by reducing the need for repeated cannulation and avoided the risk of infection and thrombosis related to peripheral cannulas. Although not a central venous catheter, midlines were found to be particularly favourable for

medium to long term venous access of up to six weeks where non vesicant or hyperosmolar medication (or fluids) were not being used (Alexandrou, Ramjan, et al., 2011).

Nurse led CVC insertion was found to improve patient safety with advantageous procedural outcomes and infection rates when compared to medical practitioner insertions. The study in Chapter Five (*Central venous catheter insertion by a clinical nurse consultant or anaesthetic medical staff: a single-centre observational study*) presented comparable insertion outcomes and favourable infection rates between a clinical nurse consultant (CNC) and anaesthetic medical staff (AMS). Approximately 80% of all insertions in both groups were uneventful and no difference was found amongst the two groups when insertion complications were compared. The infection outcomes showed a significant difference between the two groups. The proportion of catheter segments sent for pathogen testing as a matter of routine practice was similar in both the groups (AMS-42% vs. CNC-58%), however a higher colonisation rate was returned in the AMS group (AMS-23% vs. CNC-9%; $p < 0.001$). The rate of diagnosed CRBSI between the two groups also differed with the AMS group being 2.5 / 1000 catheters as opposed to 0.4 / 1000 catheters in the CNC group ($p = 0.04$) (Yacopetti et al., 2010).

Favourable procedural outcomes were also reported from the study in Chapter Six (*Nurse-led central venous catheter insertion –procedural characteristics and outcomes of three intensive care based catheter placement services*). Three nurse led CVC insertion services based in separate ICUs in hospitals across NSW Australia contributed procedural data to the Central Line Associated Bacteraemia Intensive Care Units (CLAB-ICU) project. All three services had favourable insertion outcomes with one pneumothorax (1%) and 1 arterial puncture (1%) reported. Importantly, there was only one intravascular infection during the study period (1% or 6.1 per 1000 catheters for Hospital C). The nursing infection rate was low in comparison to the medical rate (1.3 per 1000 catheters vs. 7.2 per 1000 catheters) (Alexandrou, Murgu, et al., 2011).

The study in Chapter Seven (*Central venous catheter placement by advanced practice nurses demonstrate low procedural complication and infection rates – A report From 13 years' service*), concludes the evidence that nurse led CVC insertion is safe and favourable when compared to published rates of insertion complication and infection. This study reported on outcomes from an established catheter placement service administered by specialist nursing staff over a 13 year period. A total of 4560 catheters were placed in 3447 patients. The incidence rate of pneumothorax was 0.4% using the subclavian vein and arterial puncture using the internal jugular vein was 2.2%. Complication rates were lower than published rates as did the infection rates. The average device dwell time was 14 days with a cumulative 63071 catheter days. The overall CRBSI rate was 0.2 per 1000 catheter days.

The series of studies undertaken as part of this thesis were undertaken to address the paucity of quality data to provide peer reviewed evidence that nurse-led CVAD placement can have a positive impact on patient care. The thesis has predominantly illustrated that good training and supervision, along with providing dedicated individuals with significant procedural experience, can have favourable outcomes with central venous catheter placement. This thesis provides comprehensive rationale with evidence on how specialisation with procedural volume can have greater impact on patient outcome rather than clinician grade.

Limitations of the Research:

The results from the studies undertaken in this thesis should be considered within the context of the study designs chosen. Foremost, due to the nature and speciality of the topic, a randomisation of comparison groups to provide causation, was inhibitive and could also be considered unethical. Many patients requiring catheter placement may have comorbid conditions that could put them at risk of procedural complication as part of a randomised (medical versus non-medical CVAD placement) study. Furthermore, the availability of medical staff to provide catheter insertion as required without delay for patient treatment would be difficult to achieve because of competing work demands. Earlier catheter placement was one of the main drivers for

this model care and would be clinically counterproductive. As such randomisation of medical and nursing inserters would have proven to be prohibitive even for elective cases.

An integrative literature review method was chosen for two studies in this thesis (Chapters 2 and 4). Although systematic, they are inclusive of many designs which have reduced scientific validity compared to meta analyses. Because of the paucity of evidence on the topics and the quasi experimental design of many papers, an integrative review method was required to synthesise published literature. Despite its perceived limitations against traditional scientific enquiries, integrative reviews when implemented as an empirical procedure can have scientific rigor and provide information that can be disseminated to improve clinical practice (Ellis, 1991).

Study designs which used primary data in this thesis (Chapter 4, 5 and 6) were observational. Although many scientific enquiries have used observational studies, when compared to well-planned, randomised trials, they are subject to many confounders that could bias results (Altmann, 1974). In our observational studies, selection bias may have been a contributing factor influencing our results and this was noted in the limitations of our published manuscripts. We also noted that in all observational studies, catheters were consecutive samples which may have potentially mitigated some of the selection bias.

The Future of Nurse Led Central Venous Catheter Placement

Workforce shortages in health care and the related consequences are often discussed in the literature. The need to redevelop current clinical roles within the health system is becoming an increasingly debated topic (Gallagher, Fry, & Duffield, 2010). The nursing workforce comprises nearly 50% of the global health care workforce. In Australia this proportion is 55% of the Australian health care workforce (Gaynor et al., 2007; World Health Organisation (WHO), 2006). This makes nursing pivotal in

ensuring optimal patient outcomes into the future by providing quality care through adapting to workforce and technological changes (Gallagher et al., 2010).

Advanced practice nursing is increasing in importance. As health care organisations move more and more towards patient centred care, the requirement for dedicated specialist interdisciplinary approaches will become more important. Increased medical specialisation will continue to evolve and clinical skill sets will become more compartmentalised. This increase in specialised medical workload will no doubt blur the interprofessional boundary between medical and non-medical procedural work (Dowling, Barrett, & West, 1995; Dowling et al., 1996; Fagin, 1992). Nurse led central venous catheter placement is one area where the demarcation has already been integrated and has shown through evidence presented in this thesis to be a safe alternative model of care for patients requiring central venous access as part of their treatment (Alexandrou et al., 2010b; Hamilton, 2005; Yacopetti et al., 2010).

The concept of nurse led CVC insertion was initially devised in the United Kingdom and later taken on by nurses in Australia. Since the mid 1990's only a handful of nurses in this country have the backing of medical staff and their organisation to insert these devices (Alexandrou et al., 2010a; Yacopetti et al., 2010).

Health care organisations in the US were initially not in favour of this increased specialisation of nurses even though many were inserting PICCs. In recent years, US health care facilities with the help of organisations such as the Association for Vascular Access (AVA) have started to incorporate specialist nurses to insert CVCs as a matter of organisational efficiency, cost savings and patient safety (Access, 2011; Nursing, 2009). Specialty programs have also been developed to support the education of nurses looking to increase their skills from inserting PICCS to CVCs (Access, 2012).

Specialty educational programs on CVAD insertion (for both medical and nursing) are still in their infancy in Australia where the corporate sector has taken the lead and provide short courses on ultrasound guided catheter placement. There are also some local providers within health services but no nationally accredited programs (Service, 2011). More work is required by policy makers to assist health service education in this specialty area or have the tertiary education sector engage closer with industry to develop accredited courses.

Enabling an interdisciplinary approach to central venous access that involves increasing the scope of practice for nurses to insert CVCs requires health policy makers to promote the integration of nurses developing new skills that are traditionally the area of the medical practitioner. This thesis has illustrated that outcomes from nurse led CVC placement are favourable, it also illustrated the paucity of evidence on this topic and that these advanced practice roles have been developed in a sporadic manner where the need has arisen.

Vascular access nurses that insert PICCs who want to increase their scope of practice to insert CVCs but where the need is not perceived to be required, have in the past found difficulty in establishing such a role. Such barriers to nurses undertaking advanced skills are historical and complex and are slowly being eroded. The adoption internationally of evidence based practice will give more opportunity to non-medical clinicians such as nurses to increase their scope of practice as emerging evidence demonstrates these roles to be safe and improve organisational efficiency (Cowan et al., 2006; Dunn, 2008; Kleinpell & Gawlinski, 2005). This thesis provides the scientific evidence that the increased nursing scope of practice to incorporate CVAD insertion can have many positive effects to patient health outcomes and provides some solutions to overcoming some of the universal implementation barriers.

Adoption of evidenced based practice at a local area health service or hospital level has to be driven by key clinicians showcasing the effectiveness of advanced practice

nursing and the impact it can have on patient quality of care and organisational efficiency (Hamilton, O'Byrne, & Nicholai, 1995; Strömberg et al., 2003). Outcomes from existing nurse-led services, much like the publications generated from this program of research along with future research encompassing economic modelling specifying organisation budgetary effect from reduced complications can be used to validate and further develop these roles.

Conclusions:

The series of discrete studies presented in this thesis have a significant impact on patient care and safety. Adverse events from central venous catheter placement can pose significant risk to patient safety and can contribute to morbidity and mortality. Moreover, the costs associated with such adverse events is significant and impacts greatly on health service funding models, examples were given through this thesis where the cost of treating bacteraemia associated with intravascular infection in North America is in the billions of dollars.

Nurse led central venous catheter placement has been shown through this program of research to mitigate these risks effectively. As the utilisation of VADs continue to increase, it is crucial that no concomitant increase in adverse patient outcomes attributed to these devices occurs. This thesis has provided research findings on the positive impact on patient outcomes and organisational efficiency by nurses increasing their scope of practice to include CVAD placement. It mounts a strong argument that procedural outcomes for such a clinical procedure is not influenced by clinician grade but rather training and procedural volume.

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Alexandrou, E., Ramjan, L. M., Spencer, T., Frost, S. A., Salamonson, Y., Davidson, P. M.,

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Health
South Western Sydney
Local Health District

Research and Ethics Office
Leadership · Quality · Governance

Locked Bag 7103, LIVERPOOL BC, NSW, 1871

Phone: 02 8738 8304

Facsimile: 02 8738 8310

<http://www.sswahs.nsw.gov.au/swshd/ethics/default.html>

3rd February 2014

Mr Evan Alexandrou
Clinical Nurse Specialist
Central Venous Access & Intensive Care
Liverpool Hospital

Dear Mr Alexandrou,

Re: QA2008/006 – Retrospective review of database to ascertain the complication rates of the clinicians within the CVAS.

I am writing to acknowledge receipt of your Final Progress Report dated 16th January 2014 for the above project which was reviewed and acknowledged by the *South Western Sydney Local Health District Human Research Ethics Executive Committee* at its meeting on 3rd February 2014.

We would like to take this opportunity to congratulate you on the completion of the study and look forward to receiving details of any further publications that arise from this research.

Yours sincerely,

A handwritten signature in black ink, appearing to read 'Merela Ghazal'.

Merela Ghazal
Manager, Research and Ethics Office
South West Sydney Local Health District

APPENDIX I – COPY OF SOUTH WESTERN SYDNEY AREA HEALTH SERVICE - HREC
APPROVAL FOR USE OF CLINICAL EXCELLENCE COMMISSION DATA.



Human Research Ethics Committee (Western Zone)

Locked Bag 7017, LIVERPOOL BC, NSW, 1871

Phone: 02 9612 0614

Facsimile: 02 9612 0611

10 June, 2010

Mr Evan Alexandrou
Department of Intensive Care
Liverpool Health Service
Locked Bag 7102
Elizabeth Street
LIVERPOOL NSW 2170

Dear Mr Alexandrou

**Project No: QA2010/056 – A review of nurse led central venous catheter insertion service:
clinical characteristics and outcomes**

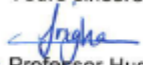
The SSWAHS Human Research Ethics Committee wishes to acknowledge receipt of your email correspondence dated 4th June, 2010 in relation to the above study. The committee reviewed the correspondence and has approved the study as a Quality Assurance project. The study has been registered for a period of 12 months and a progress report or final report will be due on 30th June, 2011.

The conditions of approval are as follows:

- (i) All data obtained is to be handled confidentially and is only to be collected by staff who would normally have access to the data and that the data does not leave the hospital. The personal details of clients/staff are not to be published in any publications and/or scientific presentations that may result as part of this study unless specific consent has been sought. Individual patient data must not leave the Department or other treatment sites in the hospital in any form, whether identifiable or potentially identifiable.
- (ii) In the event of a need to communicate with patients, relatives or external or other health professionals in order to amplify or follow-up on material in medical records, a formal application to the Ethics Committee is required to ensure that the format of the Information Sheet and Consent Form are consistent with the Area's ethical standards;
- (iii) You are to provide a copy of this letter, together with proof of identity, to the relevant Clinical Information Manager, when/if applying for access to medical records.
- (iv) All data/or results must be de-identified.

Please note the above reference number in all future correspondence regarding this project.

Yours sincerely,


R Professor Hugh Dickson
Chairperson
SSWAHS Human Research Ethics Committee

REFERENCE LIST

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