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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

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intensive care units (ICUs) in NSW and paediatric ICUs participated between March 2007 and June 2009. The project was coordinated be 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%).

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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* = 1or 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.

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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.

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