TITLE PAGE

A way to go to meet guidelines for prevention of intravenous catheter infection and complications: Audit of perioperative peripheral venous catheter care

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Author declaration

We declare that this manuscript is original, has not been published before and is not currently being considered for publication elsewhere. We confirm that the manuscript has been read and approved by all named authors and that there are no other persons who satisfied the criteria for authorship but are not listed. We further confirm that the order of authors listed in the manuscript has been approved by all of us. We understand that the Corresponding Author is the sole contact for the Editorial process (including Editorial Manager and direct communications with the office). She is responsible for communicating with the other authors about progress, submissions of revisions and final approval of proofs. We confirm that we have provided a current, correct email address which is accessible by the Corresponding Author.

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ABSTRACT

Background: Peripheral venous catheters are the most frequently used invasive medical device for care of 80% of hospitalised patients. Previous prevalence studies of peripheral venous catheter practice have identified areas for clinical practice improvement with studies addressing insertion in the emergency department, as well as insertion and care in general and oncology hospital wards. However, perioperative insertion and care have not been examined.

Objectives: To compare the clinical practice of insertion and management of perioperatively patients' peripheral venous catheters with guideline recommendations.

Methods: A prospective audit of care of 102 perioperative patients' peripheral venous catheters was performed in a 929 bed, tertiary and quaternary referral teaching hospital in Brisbane, Australia. Baseline data were collected after device insertion in the operating theatre, and postoperative data were recorded on one occasion on the following calendar day. Descriptive analyses of data were performed**.**

Results: The majority of patients (83%) had 18 or 20 gauge peripheral venous catheters inserted by skilled practitioners. Postoperatively, there were 26 (24.5%) unused catheters without ordered medical treatment. Phlebitis was reported in 3 (2.9%) patients and 7 (6.9%) patients had insecure dressings. No insertion site complications were reported for 63 (61.8%) patients. Specific site assessment was not recorded for 69 (67.6%) of cases. The overall complication rate was 10%.

Conclusion: Multiple problems were identified including failure to remove catheters without a known purpose, phlebitis, insecure dressings, non-compliant flushing practice and incomplete documentation. These problems are the recommended focus for future perioperative education to improve device management and patient care.

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INTRODUCTION

Background

Peripheral venous catheters (PVCs) are the most frequently used invasive medical device for care of hospital patients, with 330 million sold annually in the United States of America (USA) (1). It is estimated that up to 70% of patients have a PVC during their hospital admission (2). Catheter-associated blood stream infection (CA-BSI) has not been specifically studied in these frequently used catheters, even though it is an extensively researched complication in other catheter types, for example central venous catheters. PVC studies have concentrated on the complications of phlebitis, healthcare-associated infection (HCAI), local infection/colonisation and patency (2-5). Study findings indicate that up to 38% of PVCs are not necessary for treatment (6-13), but in spite of this, most patients are likely to receive a PVC as a routine part of their admission. PVCs may present a significant risk factor for CA-BSI with the incidence density of PVC-BSI estimated at 0.2 to 0.7 episodes per 1000 device days (14). This seemingly small incidence provides a considerable economic burden in Australia, costing $700 million per annum (15). Prevalence studies of PVC practice identify areas for clinical practice improvement to reduce healthcare-associated infection (HAI) (2, 5, 7, 16). These studies have audited healthcare associated infections, PVC use and the effect of infection surveillance. Goddard et al (16) reported reduced infection rates after monthly surveys which included staff feedback.

The Royal Brisbane and Women's Hospital's Executive Director of Nursing Services formed the Intravenous Access Research Council as one of four Research Councils in 2011 to improve management of PVCs, after the introduction of the Australian National Safety and Quality Health Service Standards (17). This was in particular response to the mandatory Standard 3 "preventing and controlling healthcare-associated infections". Thus, it was necessary to assess whether patients were receiving the best quality PVC care to manage infections, by the essential measurement of practice to know if there was a need for change. Local research responded with an emergency department cohort study to assess PVC insertion practice (18)

and quality studies of point prevalence surveys to evaluate PVC care in medical and cancer care patients (19, 20). These complement findings from international studies which have evaluated prevalence of PVC use and the incidence of health care associated infection in patients with peripheral intravascular access (21, 22).

New and colleagues (19) reported poor documentation of PVC care in hospital wards with inaccuracy in 37% of cases. Insertion dates and site location were poorly documented, with no record for 79 out of 186 (43%) devices. Reinserted catheters did not have the date of reinsertion for 84 of 179 (47%) catheters. These authors noted that the available space on the patient care record concentrated on insertion details, with limited space to document maintenance care. Also, polyurethane dressings were often insecure requiring replacement, and 83% of devices needing additional dressings. Russell et al (12) concurred with evidence of lack of dressing integrity and similarly found inconsistent documentation of site location, which was inaccurate for 36% of PVCs.

In view of this information, the need to audit care of PVCs inserted for perioperative management was highlighted, with no previous studies performed. In accordance with audit methodology, practice was to be compared with clinical guidelines to provide evidence-based recommendations, as this comparative method has previously provided useful insights to facilitate practice change. Identification of clinical anomalies not aligning with global guidelines and previous research (23-27) was the planned focus for care improvement. The clinical audit cycle was considered a constructive framework and systematic process to facilitate compliance with guidelines, and would provide a means for ongoing evaluation (28).

Aim

This study's overall purpose was to examine the clinical practice of PVC care in the perioperative setting to identify areas for improvement. The following study questions were asked:

What were the reasons for PVC insertion?

Which management did not match guidelines?

What complications were recorded?

How accurate was documentation?

Objectives

The study objectives were to compare the use, management, complications and documentation of PVCs in perioperative patients with guidelines, to measure compliance with standards.

METHODS

Design

A prospective audit was performed assessing the first 100 patients requiring a PVC inserted in the operating at Royal Brisbane and Women's Hospital from the population whose PVCs were to remain in situ for postoperative care, with no history of allergy to dressing/securement products and no burned/damaged skin, from 26/03/15. The project was considered by Royal Brisbane and Women's Hospital Human Research Ethics Committee as exempt from full ethical review (Ref No: HREC/14/QRBW/539).

Procedures

The study patients were identified by liaison with the consultant anaesthetist in charge of list management and individual anaesthetists, on a daily basis. Data was recorded after direct observation of patient care and from patients' care records, using a data form. Data collection was performed by a research nurse or a medical registrar assisted by a medical student. Baseline data were collected when each patient's device was inserted in the operating theatre. Postoperatively, data was collected on one visit during the following 24 hours, after patient transfer for postoperative care in either the intensive care/high dependency unit or a hospital ward.

Instrument

A review of the literature was undertaken to include previous vascular access audits and the audit tool was developed by the primary author in a format which facilitated easy completion (27). The tool was assessed by the Principal Director of the Alliance for Vascular Access Research and Teaching (AVATAR), Griffith University, and it was tested on two occasions by two data collectors. After discussion, minor modifications were made for ease of use. The assessment items of baseline and postoperative data were as per Table 1.

Figure 1. Data collection items (OT and postoperatively).

Demographics (baseline)
PVC insertion site selection/dominant arm
Documentation of PVC inserter/date and time of insertion
Catheter type/gauge
Type of dressing/device stabilisation
Insertion site visible
Type of line and infusate
Signs of phlebitis: red insertion site/pain
Estimated dwell time postoperatively, by the anaesthetist
PVC - same as OT insertion, or replaced with new PVC and reason
Condition of dressing/securement
Reason for PVC – fluid order/medication order/fluid and medication order/no order/verbal medical order to keep catheter for possible use
Flushes ordered (no infusion)
Documentation of site assessment
Dwell time (number of days since insertion)
Was infection an outcome? Details

Statistical Analyses

Data were entered into Microsoft Excel and exported for descriptive analyses with Predictive Analytics Software (IBM Corp. Released 2013. IBM SPSS Statistics for Windows, Version 22.0. Armonk, NY: IBM Corp.). Analyses included univariate testing and frequency counts which were presented as numbers and proportions.

RESULTS

Demographic and Clinical Characteristics

The demographic profiles of patients and surgery types were tabulated (see Table 1).

Table 1. Baseline demographic characteristics and surgery types of study participants (n = 102).

Variable	
Gender – male *n* (%) Gender – female *n* (%)	68 (66.7%) 34 (33.3%)
Age	Mean age 53.5 years Range 16 - 92 SD 19.43
Type of surgery *n* (%) General Neurological ENT Opthalmological Oral/Maxillofacial Orthopaedic Plastics Renal Urological Vascular	 22 (21.6%) 17 (16.7%) 10 (9.8%) 3 (2.9%) 9 (8.8%) 14 (13.7%) 16 (15.7%) 1 (1.0%) 4 (3.9%) 6 (5.9%)

All PVCs were BD Insyte™ Autoguard™ Shielded IV Catheters (BD™, North Ryde, 2015) and they were inserted by qualified, experienced medical practitioners who were either anaesthetic consultants or trainees. Size 18 or 20 gauge cannulas were inserted in the majority of 85 (83.3%) patients.

Characteristics of PVCs included reasons for PVCs, insertion sites, dressing/securement types, dressing visibility, dressing security and replacement, complications and documentation, as per Table 2.

Table 2. Peripheral Venous Catheter Characteristics (n = 102).

Characteristics	**n (%)**
Reasons for PVC:	
Fluid order	17 (16.7%)
Medication order	48 (47.1%)
Fluid and medication order	11 (10.8%)
No medical order	24 (23.5%)
Verbal medical advice “in case”	2 (2.0%)
Site of insertion:	
Hand	55 (53.9%)
Cubital fossa	21 (20.5%)
Forearm	15 (14.7%)
Wrist	5 (4.9%)
Foot	4 (3.9%)
Dominant arm	46 (45.1%)
Dressing/Securement types:	
Polyurethane dressing and non-sterile, stretchable adhesive tape	95 (93.1%)
Polyurethane dressing alone	6 (5.9%)
Polyurethane dressing with non-sterile stretchable adhesive tape and non-sterile paper tape	1 (1.0%)
Dressing visibility	
Visible	93 (91.2%)
Dressing security and replacement	
Insecure dressings replaced	4 (3.9%)
Insecure dressing not replaced	3 (2.9%)
Complications:	
Phlebitis	3 (2.9%)
Insecure dressings	7 (6.8%)
Documentation:	
Insertion dates	0 (0%)
Catheter type	0 (0%)
Catheter gauge	0 (0%)
Intravenous flush order	0 (0%)
Time of catheter removal	0 (0%)
Site assessment	33 (32.4%)

On the postoperative ward visit, 99 (97.1%) patients had the same PVC in situ as inserted in the operating theatre. There were 66 (64.7%) PVCs in situ for less than 24 hours. Due to missing documentation, total catheter dwell times were estimated with the removal time approximated to the time of completion of intravenous therapy (see Table 3).

Table 3. Frequency (%) of estimated catheter dwell times (n = 102).

Catheter Dwell Hours	Catheter in Situ at Time of Visit (Y/N)[a]	Frequency	Percent
1 to 4	N	8	7.8
5 to 8	N	9	8.8
9 to 12	N	9	8.8
13 to 24	Y	40	39.2
25 to 48	Y	22	21.6
> 48	Y	14	13.7
Total		102	100.0

[a] Y = Yes; N = No.

DISCUSSION

There were twice the number of male to female patients. Different types of surgery had a majority of male patients: Neurology 14/17 (82.4%), ENT 8/10 (80.0%), plastic surgery 11/16 (68.8%) and ophthalmology 3/3 (100%). Male patients were evenly distributed over the age range of 16 to 92. There was no specific explanation for this increased prevalence of males compared with females.

Study findings found that a quarter of PVCs were in situ without a known reason. More than half of catheters were inserted in the hand. Securement of 96% of catheters was with a non-sterile tape and there were 6.8% of dressings which were insecure. Documentation was missing for insertion dates, catheter type, catheter gauge, intravenous flush orders and time of catheter removal of all catheters.

Best practice guidelines are designed for incorporation into up-to-date policy and workplace education to guide clinical practice. Many clinical guidelines provide evidence-based recommendations worldwide, supporting policy and practice for PVC care *(26, 27, 29, 30)*. These documents inform best practice for PVC purpose, insertion site selection, methods of dressing and securement and documentation requirements.

Our results indicate non-compliance with these guidelines in many aspects of clinical practice. Our primary study objective was to report the use, management, complications and documentation of PVCs in perioperative patients, to identify lack of compliance and highlight areas of infection risk in the perioperative environment. We found that there was a high incidence of PVCs with no clear postoperative purpose in short-term patients who were recovering well. Guidelines prescribe prompt removal of catheters which are not required. Contrary to this advice, there were 26 (25.5%) catheters in patients who were stable, which either did not have a written medical order or had been left in situ following verbal medical discussion to remain "just in case" they were needed. These catheters were not recorded as flushed as per routine policy and were without documentation of checks of insertion sites and dressing integrity. No caregivers for these 26 patients had sought clarification from the treating medical team, or initiated a plan to remove the catheter, in spite of the absence of orders to provide treatment. Thus, neither nursing or medical staff seemed clear as to a plan for these PVCs regarding infection risk. This proportion of "redundant" catheters increases the burden of preventable intravascular infection (31).

Our data concurs with previous studies where 28.2% PVCs had no clear purpose (19), and 38.0% were no longer required (32). Ritchie et al acted on their similarly high occurrence of unnecessary PVCs with a program of education and follow up audits, reducing the incidence of unwanted catheters to 7.0% (7). A key recommendation for our healthcare facility is to review our prescription for PVC care to reflect current guidelines, including systematic recording of key care aspects for specified intervals of care. A cyclic program of education for caregivers is also required to ensure effective implementation of this program.

A further key finding was that documentation in the anaesthetic and patient care records was inadequate in our study. Signs of phlebitis causing PVC failure were recorded for 3 (2.9%) patients, and insecure dressings for 3 (2.9%) patients, but there was no postoperative documentation of complications at the insertion site for 92 (90.3%) patients. It was concerning that caregivers reported no complications, which is most likely an assumption when there was only insertion site documentation for 33 (32.4%) of cases. Phlebitis is an early complication, but occlusion may occur later. Thus, assumptions were made that there were no complications when documentation was incomplete or missing. Failure to document this information clearly suggests a lack of observation of the insertion site when caring for the patient, with a high possibility of a breakdown in early detection of signs and symptoms of complications. Other studies report complication rates of approximately 25% (7, 9, 12, 19), and it appears highly likely that a proportion of the patients with unreported status of their catheter insertion sites would have experienced some type of complication. Existing educational programs are in need of review to improve accuracy of observation and documentation. The educational priority is to inform practitioners of the crucial need to observe for and document the presence of PVC complications at specified timepoints, when caring for these devices. Thus, early onset of localised or catheter-related infection could be alerted.

The catheter sites with phlebitis were located in the dorsum of the hand (2) and the cubital fossa (1). Insertion in the dorsum of the hand is frequent, and if considered necessary, is preferred in the dorsal venous arch, but choice of the cephalic or basilic vein is most preferable (33). The PVC in a dorsal vein closer to the digits may have contributed to greater movement and irritation in the vein by the catheter (34). Significantly higher occlusion has been associated with PVCs in the hand and antecubital fossa, and with the infusion of antibiotics. Also, significant predictors of

accidental removal include hand or antecubital fossa insertion, compared with the forearm (33).

With 7 (6.8%) insecure dressings, but only 4 replaced, this resulted in 3 patients at high risk for accidental catheter removal and catheter-related or local infection. A secure, dry dressing importantly reduces the risk of infection, and together with a dedicated securement device will guard against accidental removal (35). The makeshift nature of adding non-sterile tape to secure the borders of a sterile dressing as observed in 95 (93.1%) patients, suggests a recognition that simple occlusive polyurethane dressings are inadequate. This has been acknowledged in previous studies of dressing and securement, where other technologies such as bordered polyurethane and dedicated securement devices are preferred (19, 36-38). Review of standard dressing/securement of PVCs in the perioperative environment is recommended, with selection of standard dressing and securement devices from new technologies which include cloth adhesive borders and are dedicated to secure the intravenous device.

Data of catheter flushing in relation to administration of medications indicated that flushing the catheter at the appropriate time-points was most likely not well performed. Inadequate flushing could contribute to the patient's risk of phlebitis in relation to medication administration with the added inconvenience of discomfort and pain, but may not impact on catheter failure (39, 40). The absence of ordered flushes for any patient was of concern. With 59 (57.9%) patients prescribed postoperative intravenous medication including 24 (23.5%) prescriptions for antibiotic therapy, this is a surprising finding since only 28 (27.5%) patients had a postoperative intravenous line in place. This indicates a low compliance to hospital policy which requires flushing pre and post medication administration and every 8 hours, without attached lines.

The overall complication rate of 10% is less than the reported 25% complication rate in other clinical studies of PVC practice (7, 9, 12, 19). This is likely due to the short term use of less than 24 hours for 65% catheters in our study, as well as under-reporting. Systems problems need to be addressed to facilitate accurate perioperative documentation and promote optimal care of PVCs. These audit findings indicate an urgent need for review of current clinical practice.

LIMITATIONS

Our study was limited in that data was collected at the time points of insertion, during one postoperative visit and from the patient record. This provides only a snapshot of PVC use, management and documentation, but includes invaluable baseline information for continuing audits of perioperative PVCs and development of an audit cycle.

CONCLUSIONS

Multiple problems with PVC management included failure to remove catheters without a known purpose, phlebitis, insecure dressings, uncertainty in ordering/documentation of flushing procedures, perceived inadequacy of simple polyurethane dressings and incomplete documentation. These problems are the recommended focus for future perioperative education and systems development. Many patients in the operating theatre and postoperative care are at risk of having peripheral PVCs inadvertently dislodged, or suffering other mechanical or infective complications which result in catheter failure. The available studies of PVCs which investigate complications suggest that catheter failure may be prevented by improved catheter dressing and securement, so a better process of workflow and communication between the anaesthetic team and ward nurses will be promoted to facilitate improved care. Continuation of this audit cycle in perioperative care will lead to ongoing improved practice when caring for PVCs, so as to minimise catheter-related complications such as infection.

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