Central venous catheters: a survey of ICU practices

Claire M. Rickard BN RN GradDipN (CritCare), PhD Student, School of Nursing, Queensland University of Technology, Brisbane, Queensland, Australia; Lecturer, School of Rural Health, Monash University, Traralgon, Victoria, Australia; and Department of Intensive Care Medicine, Royal Brisbane and Women's Hospital, Brisbane, Queensland, Australia
Mary Courtney BAdmin PhD RN MHP and Professor of Nursing, School of Nursing, Queensland University of Technology, Brisbane, Queensland, Australia; and Honorary Research Consultant, Royal Brisbane and Women's Hospital, Brisbane, Queensland, Australia
Joan Webster BA RNNursing Director, Research, Centre for Clinical Nursing, Royal Brisbane and Women's Hospital, Brisbane, Queensland, Australia

Author copy of an article published in
Journal of Advanced Nursing (2004); 48 (3) p247- 256

Aim. This paper describes the current infection control practices for CVC care and compares these to evidence-based practice guidelines.

Background. Intensive care patients with central venous catheters (CVCs) are at risk of catheter-related infection, which increases morbidity, mortality and health care costs. Infection control practices, including care of intravenous administration sets and catheter sites, are undertaken by nurses in an attempt to avoid infection. Although practice guidelines are available, infection control practices may vary between practitioners and institutions; however, current practice has not been formally surveyed.

Method. A prospective, cross-sectional descriptive survey was carried out. Intensive care units (n = 14) in Australia were surveyed about their infection control policies for CVC care. Results were tabulated and compared with evidence-based practice guidelines.

Results. A wide variety of responses was received about duration of administration set use for standard, parenteral nutrition and propofol (lipid-based anaesthetic) infusions; ad hoc administration set connection technique; dressing frequency, materials and solutions; and barrier precautions used during procedures. There was inconsistent adherence to the guidelines.

Conclusion. There is variation in the infection control approach to CVC care. Greater adherence to existing Centers for Disease Control Guidelines would assist in the standardization of best practice and facilitate evidence-based care.

What is already known about this topic
Patients with central venous catheters are at risk of catheter-related infection, which increases morbidity, mortality and health care costs.

Many nursing practices attempt to minimize infective risk, although not all are supported by evidence.

The Centers for Disease Control provide evidence-based practice guidelines for the prevention of infection and care of central venous catheters.

What this paper adds

The state of current nursing practice with regards to infection control with central venous catheters.

The level of adherence by nurses to the Centers for Disease Control practice guidelines.

Recommendations for nursing practice, education and future research.

Background

Many patients, particularly those in intensive care units (ICUs), have a central venous catheter (CVC) for the administration of fluid, nutrition and medication, or for intravascular monitoring. CVCs break the body's natural defence barrier (the skin), and so put the patient at risk of catheter-related infection, of which an estimated 200,000 cases occur worldwide each year (Mermel 2000). Catheter-related infection is devastating, with increased suffering and risk of death for patients, and increased institutional costs due to the increased length and complexity of hospital admission (Pittet et al. 1994).

The CVCs are requested and inserted by physicians; however post-insertion catheter care is predominantly a nursing responsibility, providing an opportunity for nursing care to influence infection rates. Many practices are used to minimize infection risk, including procedures involving the intravenous administration sets and catheter entry sites. Varying levels of evidence exist for the efficacy of infection control procedures involving CVC care; however this is improving as more research is undertaken and published.

The Centers for Disease Control (CDC) (Atlanta, GA, USA) is an important infection control body that has been influential in reviewing the evidence for effective infection prevention measures in many areas, including intravascular therapy. The CDC published guidelines for the prevention of intravascular catheter-related infection in 1981 (CDC 1981), 1996 (Pearson 1996), and most recently in 2002 (O'Grady et al. 2002). The Guidelines were developed by a multidisciplinary group of health care professionals, are evidence-based, and provide recommendations for best practice. Their goal is to promote patient safety and to decrease preventable infections (O'Grady et al. 2003). A wide variety of related topics is covered, including administration sets, injection ports, site care, and dressing regimes. In addition to general guidelines, specific guidelines are provided for various catheters, including CVCs.

Although the CDC Guidelines have existed for the past two decades, little is known about what practitioners actually do in clinical practice, and how closely practice reflects the Guidelines. There is only one previous investigation into this area, and this was a practice survey conducted in 1992 (Clemence et al. 1995) using a

questionnaire with nurses involved with CVCs in hospital or home settings in the USA. The investigated topics relevant to nurses included catheter site care (dressing type, frequency, antiseptic solutions, technique and protective garments). A range of practices was reported, and these were not always consistent with the evidence-based guidelines current at that time. These data support anecdotal reports of wide procedural variation in CVC infection control practice. However, as this was a single study, undertaken in one country, and is now a decade old, we considered that an investigation of current practice was required.

The study

Aim

The aim of the study was to describe current infection control practices regarding CVC care in Australian ICUs and to compare practice with evidence-based practice guidelines.

Design

A prospective, cross-sectional, descriptive survey was carried out.

Sample

The sample was Australian ICUs (n = 14), with representation from each State and Territory.

Questionnaire

A questionnaire was developed using the CDC Guidelines for the Prevention of Intravascular Catheter-Related Infections (Pearson 1996, O'Grady et al. 2002). The relevant sections used were: Hand hygiene; Aseptic technique during catheter insertion and care; Catheter site care; Catheter-site dressing regimes; Replacement of administration sets; and IV-injection ports (see Table 1). The questionnaire was validated by a reference group composed of expert ICU nurses, who considered the research questions and the CDC Guidelines, pilot-tested the questionnaire, and determined that it accurately reflected the phenomena of interest. Demographic data were obtained to describe the ICU, patient population and the types of catheters used.

Infection control procedure	Current practice	CDC Guidelines (O'Grady *et al.* 2002)	Level of evidence*
Duration of administration set use for standard infusions		IX.A.1. 'Replace administration sets, including secondary sets and add-on devices, no more frequently than at 72-hour intervals…' (O'Grady *et al.* 2002, p. 15)	IA
Duration of administration set use for total parenteral nutrition infusions		IX.A.2. 'If the solution contains only dextrose and amino acids, the administration set does not need to be replaced more frequently than every 72 hours'(O'Grady *et al.* 2002, p. 15)	II
Duration of administration set use for lipid emulsion infusions		IX.A.2. 'Replace tubing used to administer blood, blood products, or lipid emulsions (those combined with amino	IB

Infection control procedure	Current practice	CDC Guidelines (O'Grady *et al.* 2002)	Level of evidence*
		acids and glucose in a 3-in-1 admixture or infused separately) within 24 hours of initiating the infusion' (O'Grady *et al.* 2002, p. 15)	
Duration of administration set use for propofol infusions		'IX.A.3. 'Replace tubing used to administer propofol infusions every…12 hours,…as per the manufacturer's recommendation (for infusions)' (O'Grady *et al.* 2002, p. 15)	IA
Decontamination of CVC hub-administration set connection prior to every connection/disconnection of an administration set		X.A. Clean injection ports with 70% alcohol or an iodophor before accessing the system' (O'Grady *et al.* 2002, p. 15)	IA
		III.A. 'Observe proper hand-hygiene procedures either by washing hands with conventional antiseptic-containing soap and water or with waterless alcohol-based gels or foams. Observe hand hygiene before and after… accessing… (or) repairing…an intravascular catheter' (O'Grady *et al.* 2002, p. 13)	IA
CVC dressing type		VII.A. 'Use either sterile gauze or sterile, transparent, semi-permeable dressing to cover the catheter site' (O'Grady *et al.* 2002, p. 14)	IA
		VII.C. 'If the patient is diaphoretic, or if the site is bleeding or oozing, a gauze dressing is preferable to a transparent, semi-permeable dressing' (O'Grady *et al.* 2002, p. 14)	II
		VI.D. 'No recommendation can be made for the use of chlorhexidine sponge dressings to reduce the incidence of infection' (O'Grady *et al.* 2002, p. 18)	Unresolved issue
		VI.E. Do not use chlorhexidine sponge dressings in neonates aged <7 days or of gestational age <26 weeks' (O'Grady *et al.* 2002, p. 18)	II
Maximum time that CVC dressings are left intact		VI.C.1 'Replace catheter-site dressing when it becomes damp, loosened, or soiled or when inspection of the site is necessary' (O'Grady *et al.* 2002, p. 17)	IA
		VI.C.2 'Replace dressings used on short-term CVC sites every 2 days for gauze dressings and at least every 7 days for transparent dressings, except in those paediatric patients in which the risk of dislodging the catheter outweighs the benefit of changing the dressing' (O'Grady *et al.* 2002, p. 17)	IB
Solution used for CVC site care		VI.A.1. Disinfect clean skin with an appropriate antiseptic…during dressing changes. Although a 2% chlorhexidine-based preparation is preferred, tincture of iodine, an iodophor, or 70% alcohol can be used' (O'Grady *et al.* 2002, p. 14)	IA

Infection control procedure	Current practice	CDC Guidelines (O'Grady *et al.* 2002)	Level of evidence*
		VI.A.2. No recommendation can be made for the use of chlorhexidine in infants aged <2 months (O'Grady *et al.* 2002, p. 14)	Unresolved issue
Barrier precautions are used for CVC care		IV.C. 'Wear clean or sterile gloves when changing the dressing on intravascular catheters' (O'Grady *et al.* 2002, p. 14)	IC
		III.B. 'Use of gloves does not obviate the need for hand hygiene' (O'Grady *et al.* 2002, p. 13)	IA
*Level of Evidence: IA, strongly recommended for implementation and strongly supported by well-designed experimental, clinical, or epidemiologic studies; IB, strongly recommended for implementation and supported by some experimental, clinical, or epidemiologic studies, and a strong theoretical rationale; IC, required by (U.S.) state or federal regulations, rules or standards; II, suggested for implementation and supported by suggestive clinical or epidemiologic studies or a theoretical rationale; Unresolved issue, represents an unresolved issue for which evidence is insufficient or no consensus regarding efficacy exists.			
CDC, Centers for Disease Control; CVC, central venous catheter.			

Table 1 Questionnaire for comparison of current practice with CDC Guidelines

Data collection

The ICUs were contacted by telephone and invited to participate following an explanation of the survey purpose. The questionnaire was then administered by telephone interview with the charge nurse or senior nurse on duty. Respondents were asked to give answers that reflected unit policy or the predominant unit practice if no formal policy existed. Participants' answers were responded to during the interview in an impartial manner, with no discussion or inference as to the correctness of responses.

Ethical considerations

Institutional Ethics Committee approval was not required, as the practice survey had no impact on patient care or confidentiality. An explanation of the survey was provided over the telephone and completion of the questionnaire was assumed to imply consent. Confidentiality of individual and institutional responses was protected.

Data analysis

Continuous variables were calculated for range, mean and standard deviation values. Categorical data was described using percentages and frequencies. Some responses were given in hours, days or frequencies per week. To allow comparison of these data, they were transformed into hourly data, for example procedures performed twice weekly (alternating every third then fourth day) were classified as a maximum of 96 hours. All analysis was undertaken used the Statistical Package for the Social Sciences version 10·0 (SPSS®, Chicago, IL, USA). A comparison was made of all responses with the relevant CDC Guidelines for the Prevention of Intravascular Catheter-Related Infections. These were last updated in 2002 (O'Grady et al. 2002), although the 1996 version (Pearson 1996) was in place for the period of this survey.

The minor relevant variations between the two versions of the Guidelines were accounted for during data analysis.

Results

Sample

All of the 14 ICUs agreed to complete the questionnaire, and all were in public (government-operated) teaching hospitals in metropolitan or major regional areas (see Table 2). A combination of plain and antimicrobial catheters was used routinely in all units.

Size of ICU		Patients admitted per year	
Beds	**Sample**	**Patients**	**Sample**
≤6	3	≤500	4
7–14	6	501–1199	3
15–24	5	1200–1500	7
ICU, intensive care unit.			

Table 2 Characteristics of participating ICUs

Duration of intravenous administration set use

Standard infusions (crystalloid or crystalloid-based)

A wide range of responses (72168 hours) was given, with a mean of 114·9 hours (sd 43·3), which equates to just under 4 days of use. The most frequent responses were at the two extremes, with 5 units each reporting use of 72 and 168 hours (see Table 3). The CDC Guidelines recommend that administration sets for these infusions are replaced no more frequently than every 72 hours.

Infusion type	Set usage* (hours)	No. of ICUs	%
Standard	***≥72***	***14***	***100***
	<72	0	0
TPN	***≥72***	***10***	***71***
	<72	4	29
Lipid	***≤24***	***10***	***71***
	>24	4	29
Propofol	***≤12***	***2***	***14***
	>12	12	86
*Data in bold italics represent the recommended duration of administration set use as per the CDC Guidelines for the Prevention of Intravascular Catheter-Related Infections.			
CDC, Centers for Disease Control; TPN, total parenteral nutrition.			

Table 3 Reported maximum duration of intravenous administration set use compared with the CDC Guidelines

Total parenteral nutrition

The response range was also wide, from 24 to 168 hours, with a mean reported maximum usage of 87·4 hours (sd 53·8), which equates to 3·6 days of use. The most commonly occurring response was 24 hours (see Table 3). The ICUs which infused a non-lipid total parenteral nutrition (TPN) solution (amino acids and dextrose) and a separate lipid emulsion reported identical usage timeframes for the administration sets. The CDC Guidelines recommend replacement of administration sets used for non-lipid TPN no more frequently than every 72 hours, but a shorter 24-hour usage for lipid-containing TPN and for separate lipid emulsions.

Propofol

The ICUs most frequently reported a 72-hour maximum usage for propofol administration sets, but again, the range of responses was wide, from 12 to 168 hours (mean 96·0, sd 50·5) (see Table 3). The CDC Guidelines recommend 24-hour administration set use for lipid emulsions such as propofol.

Ad hoc administration set change procedure

The majority of units (64%) reported that they swabbed the catheter-set connection when reconfiguring an administration set at a time other than initial catheter insertion or routine set change. The predominant technique involved a 70% alcohol prepackaged swab, but others reported using chlorhexidine or alcoholic chlorhexidine. The 1996 Guidelines recommended that the catheter hub be decontaminated before accessing the administration set, although a specific antiseptic was not stated. This procedure is no longer covered in the 2002 version of the Guidelines; however, it is reasonable to generalize the recommendations for accessing injection ports to the accessing of the administration set, as both involve breaking the sterile circuit and potentially allow microbial contamination. The Guidelines recommend that injection ports be cleaned immediately prior to use with 70% alcohol or an iodophor (e.g. Betadine®; Purdue-Pharma L.P., Stanford, CT, USA).

Dressing material

Semi-permeable transparent dressings were predominantly in use, with gauze dressings reported by only one unit (see Table 4). The Guidelines equally recommend both of these dressings except in cases of severe diaphoresis or a bleeding or oozing catheter site, in which case gauze dressings are preferred.

	No. of ICUs	**%**
Type		
Transparent semi-permeable	***13***	***93***
Gauze	***1***	***7***
Frequency		
Transparent semi-permeable		
≤Weekly	***11***	***85***
>Weekly	2	15
Gauze		

	No. of ICUs	%
≤48 hours	***0***	***0***
>48 hours	1	100
Solution		
2% Chlorhexidine	***0***	***0***
Tincture of iodine/iodophor	***3***	***21·5***
70% Alcohol	***3***	***21·5***
70% Alcohol/0·5% chlorhexidine	3	21·5
Saline	3	21·5
Chlorhexidine sponges	2	14
*Data in bold italics represent the recommended CVC site care as per the CDC Guidelines for the Prevention of Intravascular Catheter-Related Infections.		
CVC, central venous catheter; CDC, Centers for Disease Control; ICU, intensive care unit.		

Table 4 Reported frequency and type of CVC site care compared with the CDC Guidelines

Dressing frequency

A wide range of answers from 72 to 240 hours was reported for frequency of semi-permeable transparent dressing replacement, with a mode of 168 hours and mean of 142·2 hours (sd 59·2). The one unit using gauze dressings replaced these at a maximum of 96 hourly intervals (see Table 4). The 1996 version of the CDC Guidelines considered dressing frequency to be an unresolved issue and gave no recommendations. The revised 2002 CDC Guidelines advocate replacement of gauze dressings every other day and at least weekly replacement of semi-permeable transparent dressings. Many units commented that in addition to the routine timeframes, dressing changes were performed as necessary. Reasons for this were not requested. The Guidelines advise that dressings also be replaced if they are damp, loose or soiled, or for site inspection.

Dressing solutions

Most units reported use of antimicrobial products for postinsertion catheter site care. Reponses were almost evenly divided between five products (see Table 4). The 1996 CDC Guidelines did not include any recommendation for antimicrobial solution use during CVC dressing. The revised 2002 Guidelines recommend that skin be disinfected during dressing changes with a 2% chlorhexidine-based preparation (for patients over 2 months of age); however, tincture of iodine, an iodophor (e.g. Betadine®), or 70% alcohol are also acceptable. Use of a chlorhexidine impregnated sponge (BiopatchTM) is considered an unresolved issue by the CDC and no recommendations are made for its use.

Barrier precautions

Protective garments were worn in 57% of units to perform a dressing or routine administration set change. Plastic non-sterile aprons were most commonly used, followed by non-sterile and then sterile cloth gowns. All units reported wearing

gloves (sterile 57%, non-sterile 43%) to perform a CVC dressing or routine administration set change. Most did not use masks, although 14% reported wearing a mask for processes involving TPN.

The CDC Guidelines do not advise the use of protective garments for CVC care and state that masks are only to be used when admixing TPN, a procedure that is now generally performed in a pharmacy rather than an ICU. The Guidelines recommend that gloves should be worn for a dressing change, but whether these should be sterile or non-sterile is an unresolved issue. It is further noted that proper hand hygiene (with antiseptic containing soap and water or waterless alcohol-based gels or foams) must be attended to before and after the procedure, in addition to the use of gloves. The Guideline recommendations for accessing administration sets include no reference to gloves, but do state the necessity for proper hand hygiene as above.

Discussion

The survey found only two areas of infection control practice that were totally adherent to the CDC Guidelines: duration of administration set use for standard infusions and type of catheter dressing. The 100% Guideline adherence for use of general infusion administration sets is probably explained by the non-specific nature of the recommendation; that is, sets are recommended to be replaced no more frequently than at 72 hours, rather than giving a definite optimal duration of usage. The broad nature of this recommendation meant that, although there was a large variation in the reported timeframes used (72168 hours), they were all Guideline compliant.

The results displayed two strong trends. First, one-third of ICUs reported replacing administration sets 72 hourly, which suggests that the Guidelines may be misinterpreted as recommending a maximum rather than a minimum 72 hours of use. Conversely, another third of ICUs used administration sets for 168 hours (1 week). This timeframe is within the broad Guidelines, but is far removed from the well-researched 72-hour interval, although reports are beginning to appear in the literature supporting longer administration set use (Raad et al. 2001, Rickard et al. 2002). There has been no published evaluation of the inherent efficacy of routinely replacing sets, although occasionally it is noted the practice may have no effect at any time interval (Maki et al. 1987, Ducharme et al. 1988). Routinely changing administration sets before 1 week, or indeed at any time, may be a waste of time and resources. However, until a randomized controlled trial supports use to beyond 1 week, it would be prudent to limit administration-set use to this, rather than an unlimited time.

Semi-permeable transparent dressings seem to be predominantly used in Australian ICUs, with all respondents reporting this dressing type, with the exception of one unit using gauze. The CDC equally recommends these two dressing types. This is consistent with a recent systematic review which found no difference between the products and attributed this to the small sample sizes studied to date (Gillies et al. 2003). In cases of diaphoresis or a bleeding or oozing catheter site, gauze dressings are recommended by the CDC. Our survey did not seek to address these special circumstances and we cannot say whether Australian ICU nurses substitute gauze dressings in these cases.

The study identified several infection control practices that were not in accordance with the CDC Guidelines and thus are areas for potential practice improvement. These were: duration of administration set use for TPN and lipid emulsions, including propofol; the procedure for ad hoc administration set changes; frequency of dressing replacement; antimicrobial solution used when dressing the catheter site; and barrier precautions used for catheter care.

Many ICUs are currently replacing non-lipid TPN administration sets more frequently, and lipid sets (including propofol) less frequently than the Guidelines recommend. Historically, all TPN sets were thought to carry a significantly higher microbial growth risk, but more recent data suggest that it is the lipid emulsion which is responsible (Didier et al. 1998, Matlow et al. 1999). Our respondents did not differentiate between lipid emulsion-only solutions and other forms of TPN and rarely recognized that propofol, a frequently used ICU infusion, is a lipid emulsion. This is a potential avenue for further education and practice change.

Many units reported complex infection control precautions for replacement of administration sets at routine intervals. In contrast, there was a lack of rigour in the approach used to decontaminate connections when replacing sets intermittently. Administration set configurations are not static throughout the catheterization period, but are manipulated frequently to add, remove or reconfigure infusions. A thorough reading of the entire CDC Guidelines supports the fact that hand hygiene and set decontamination should be attended in this situation. However, there is no specific recommendation covering the procedure, and this may at least partially explain the high level of practice uncertainty. It may be beneficial for future versions of the Guidelines to specifically outline the recommended procedure for intermittently connecting/disconnecting administration sets.

The reported frequencies for dressing replacements were not all consistent with the current CDC Guidelines and a wide range of timeframes was quoted. This is perhaps due to the 1996 Guidelines (in place during the study) giving no recommendation for CVC dressing frequency. In order to comply with the 2002 Guidelines, some units will need to change dressings more frequently. Many respondents commented that additional dressings were performed as necessary. This is consistent with the Guidelines, which recommend replacement if the dressing is damp, loosened or visibly soiled. Whilst frequency of gauze dressings is definitively addressed, the Guidelines for replacing semi-permeable transparent dressings are broad, giving a minimum (weekly) rather than a finite timeframe. This is no doubt because of the limited amount of quality published research on the topic, with only one study (Rasero et al. 2000) cited by the Guidelines.

The 1996 Guidelines also made no mention of the practice of decontaminating the catheter site during dressing replacements. Despite this, all units reported the practice as standard. The updated Guidelines now recommend that skin be disinfected during dressing changes with one of three solutions. Current practice, which involves a large variety of antimicrobial products, as well as saline, will need to be adapted accordingly. Although the Guidelines allow other solutions, 2% chlorhexidine is recommended. This is supported by a recent meta-analysis of 4143 catheters, which showed a halving of infection risk when chlorhexidine rather than 10% povidineiodine was used for insertional and ongoing catheter site care

(Chaiyakunapruk et al. 2002). The analysis included chlorhexidine at concentrations of 0·51·0% in alcohol and 0·52·0% in aqueous, which suggests that levels lower than the CDC recommended 2% are acceptable. The most recently available site-care product, chlorhexidine-impregnated sponges (BiopatchTM), are being used in some centres in Australia, despite their increased cost. However, the Guidelines state that there is inadequate research evidence at this time to recommend their use.

The CDC Guidelines do not advocate protective garments for CVC dressings or administration set changes, yet a number of units used these routinely. Under standard precautions, unless soiling with blood or body fluids is anticipated, gowning of any type is unnecessary, costly and should be abandoned. All ICUs reported use of sterile or non-sterile gloves to perform dressings. Both glove types are acceptable for dressing replacement under the Guidelines, but are recommended purely as standard precautions, that is, to protect staff from possible body fluid exposure rather than to prevent catheter infection. Units currently using the more expensive sterile gloves should consider changing to the clean, non-sterile variety. All units also reported wearing gloves routinely to replace administration sets. This is not a situation where exposure with blood or body fluids should be anticipated (unless dis/connecting a blood-product infusion), is not recommended by the Guidelines, and should be discontinued. A small number of units reported the use of masks whilst manipulating TPN administration sets. The CDC Guidelines do not recommend masks for this procedure and units should avoid this unnecessary practice. The Guidelines do recommend stringent attention to hand hygiene and aseptic technique for all aspects of CVC care.

The predominant findings of this study were the wide diversity of current practice involving infection control care of CVCs, and lack of consistent adherence to the CDC Guidelines. These findings are consistent with a survey on CVC care undertaken in the USA in 1992, which also found varied practice and divergence from CDC Guidelines (Clemence et al. 1995). Sub-optimal compliance with practice guidelines has also been observed in other infection control studies in the areas of hand hygiene, glove use, needle recapping, and respiratory isolation (White et al. 1997, Tait et al. 2000, Harbath et al. 2002, Stein et al. 2003).

Limitations

There are some limitations to the study. The sample size was small and limited to one country, and therefore cannot be interpreted as representative of all ICU practice. However, it did include participants from each Australian State and Territory and the results give some indication of Australian practice. The decision to administer the questionnaire to the senior nurse on duty, and request information on unit policy or predominant unit practice, assumed that the nurse would know this information and would give an accurate answer. It is possible however, that responses actually reflected the individual's practice bias or a perception of the 'right' answer. The one previous practice survey on this topic also involved a senior nursing sample, and a practice questionnaire was distributed to attendees at a professional conference (Clemence et al. 1995). Results from self-report questionnaire surveys such as ours are subject to limitations, in that self-reported infection control adherence may be overestimated compared with that measured by independent observers (Henry et al. 1994). An observational design would have provided a more direct measure of infection control practice, although such studies require increased resources and, if

participants know that they are being observed, the Hawthorne effect may lead to behaviour being modified (Henry et al. 1994, Harbath et al. 2002). We did not have the resources to undertake a multi-centre observational study and instead used the questionnaire method, as have previous studies seeking to describe elements of infection control practice (Alvaran et al. 1994, Clemence et al. 1995, Beaujean et al. 2000, Tait et al. 2000).

Conclusions

Although the study revealed a significant level of discrepancy between the CDC Guidelines and current practice, they do not explain why such discrepancies exist. The Guidelines are the most useful evidence-based document currently available for intravascular catheter care and are widely published and cited, and it is reasonable to expect that they should be reflected in clinical practice. Why is this not happening? Whilst we do not assume that all individual nurses would be familiar with the CDC Guidelines, those responsible for the development or updating of unit policies should be. Additionally, it is important periodically to search the literature for relevant studies published after the Guidelines' publication and adapt policy and practice accordingly. Our finding that there is lack of adherence to evidence in unit policies almost certainly reflects a lack of resources or appropriate staffing to allow policies to be developed that reflect the current literature. Clinical policy development in Australia is often undertaken by nurses with advanced clinical skills but limited experience in information retrieval and analysis. It would be beneficial for institutions to provide further support and education in policy development, and to encourage clinical nurses to develop policies in consultation with local nurse researchers, academics and other appropriate staff, such as librarians.

The use of CVCs in large numbers and for extended periods of time is a relatively new phenomenon, and some aspects of CVC care have not yet been fully investigated. The CDC Guidelines are based on the best available evidence, but in some cases recommendations cannot be given because of inadequate or conflicting research. This may limit the perceived usefulness of the Guidelines by clinicians. Nurses have been introduced to an evidence-based culture relatively recently, and the knowledge-practice gap is a well-known problem (Retsas & Nolan 1999, Pearson 2002). In recent years, antimicrobial catheters have been extremely effective in lowering catheter infection rates (Veenstra et al. 1999) and are used widely, although the CDC recommends their use only if infection rates remain a concern after all other basic precautions have been taken. In our study, almost all units reported using antimicrobial catheters as standard. Perhaps the use of these catheters has led to a complacent attitude to traditional anti-infective precautions, such as those covered in this study. Staff education about antimicrobial catheters should emphasize their role as an adjunct to, not a replacement for, basic principles of infection control.

For the purposes of the study, we assumed that clinical practice guidelines are beneficial to patients and that they should be reflected in good practice. It could perhaps be argued that reliance on guidelines detracts from individual professional accountability. Ideally, all nurses would frequently review the research literature and incorporate relevant findings into practice; however, realistically, busy clinicians may not have the time, skills or inclination to do so. Clinical practice guidelines aim to facilitate evidence-based practice, decrease practice variation, and promote cost-effective care (O'Grady 2003). Guidelines developed by reputable organisations such

as the CDC are a useful tool for navigating the published evidence, which continues to grow in both quantity and complexity. The CDC Guidelines provide guidance on care interventions that are effective both individually and in total. Recent data from 2043 ICU patients showed a 57% reduction in catheter-associated bloodstream infection in the 13 months after the provision of a comprehensive educational intervention based on the CDC Guidelines (Warren et al. 2003). We contend that by providing Guideline-compliant care, nurses can demonstrate that they are delivering high quality nursing care for patients with CVCs.

Recommendations

On the basis of the study, we recommend that:

1. Individual units review their policies and procedures for care of CVCs, with particular reference to the CDC Guidelines. Our questionnaire may be a useful quality audit tool for practice review.

2. Where diversity of practice is found, education and motivation for staff should be given about the 2002 CDC Guidelines and these should be formalized in the relevant institutional policies.

3. Further research is undertaken to resolve contentious or unsupported aspects of CVC care, and to evaluate effective ways to ensure that clinicians are aware of, and comply with, evidence-based practice guidelines. The research should be of rigorous scientific design and execution, including large multi-site, randomized controlled trials where appropriate. Specific areas requiring further investigation include:

the optimal maximum duration of administration set use.

the decontamination technique to be used when connecting administration sets on a routine or ad hoc basis.

the optimal frequency for CVC dressing replacement.

the efficacy of barrier precautions when manipulating administration sets or site dressings.

the efficacy of chlorhexidine-impregnated sponges for CVC site care.

Acknowledgements

We thank the ICU nurses who participated in the survey for giving their time and sharing their practice.

References

Alvaran M.S., Butz A. & Larson E. (1994) Opinions, knowledge, and self-reported practices related to infection control among nursing personnel in long-term care settings. American Journal of Infection Control 22, 367370.

• Beaujean D.J.M., Weersink A.J.L., Troelstra A. & Verhoef J. (2000) Consice communications. A pilot study on infection control in 10 randomly selected European

hospitals: results of a questionnaire survey. Infection Control and Hospital Epidemiology 21, 531534.

• CDC (1981) Guideline for prevention of intravenous therapy-related infections. Infection Control 3, 6272.

• Chaiyakunapruk N., Veenstra D.L., Lipsky B.A. & Saint S. (2002) Chlorhexidine compared with povidine-iodine solution for vascular catheter-site care: a meta-analysis. Annals of Internal Medicine 136, 792801.

• Clemence M.A., Walker D. & Farr B.M. (1995) Central venous catheter practices: results of a survey. American Journal of Infection Control 23, 512.

• Didier M.E., Fischer S. & Maki D.G. (1998) Total nutrient admixtures appear safer than lipid emulsion alone as regards microbial contamination: growth properties of microbial pathogens at room temperature. Journal of Parenteral and Enteral Nutrition 22, 291296.

• Ducharme F.M., Gauthier M., Lacroix J. & Lafleur L. (1988) Incidence of infection related to arterial catheterization in children: a prospective study. Critical Care Medicine 16, 272276.

• Gillies D., O'Riordan E., Carr D., O'Brien I., Frost J. & Gunning R. (2003) Central venous catheter dressings: a systematic review. Journal of Advanced Nursing 44, 623632.

• Harbath S., Pittet D., Grady L., Zawacki A., Potter-Bynoe G., Samore M.H. & Goldmann D.A. (2002) Interventional study to evaluate the impact of an alcohol-based hand gel in improving hand hygiene compliance. Pediatric Infectious Disease Journal 21, 489495.

• Henry K., Campbell S., Collier P. & O'Boyle Williams C. (1994) Compliance with universal precautions and needle handling and disposal practices among emergency department staff at two community hospitals. American Journal of Infection Control 22, 129137.

• Maki D.G., Botticelli J.T., LeRoy M.L. & Thielke T.S. (1987) Prospective study of replacing administration sets for intravascular therapy at 48- vs 72-hour intervals. 72 hours is safe and cost-effective. JAMA The Journal of the American Medical Association 258, 17771781.

• Matlow A.G., Kitai I., Kirpalani H., Chapman N.H., Corey M., Perlman M., Pencharz P., Jewell S., Phillips-Gordon C., Summerbell R. & Ford-Jones E.L. (1999) A randomised controlled trial of 72- versus 24-hour intravenous tubing administration set changes in newborns receiving lipid therapy. Infection Control and Hospital Epidemiology 20, 487493.

• Mermel L.A. (2000) Prevention of intravascular catheter-related infections. Annals of Internal Medicine 132, 391402.

• O'Grady N.P. (2003) On the road to avoiding adverse events: educational programs pave the way. Critical Care Medicine 31, 20772078.

• O'Grady N.P., Alexander M., Dellinger E.P., Gerberding J.L., Heard S.O., Maki D.G., Masur H., McCormick R.D., Mermel L.A., Pearson M.L., Raad I.I., Randolph A. & Weinstein R.A. (2002) Guidelines for the prevention of intravascular catheter-related infections. MMWR Morbidity and Mortality Weekly Report 51, 129.

• O'Grady N.P., Gerberding J.L., Weinstein R.A. & Masur H. (2003) Patient safety and the science of prevention: the time for implementing the Guidelines for the Prevention of Intravascular Catheter-Related Infections is now. Critical Care Medicine 31, 291292.

• Pearson M.L. (1996) Guideline for prevention of intravascular device-related infections. American Journal of Infection Control 24, 262293.

• Pearson A. (2002) Nursing research. International Journal of Nursing Practice 8, 287288.

• Pittet D., Tarara D. & Wenzel R.P. (1994) Nosocomial bloodstream infection in critically ill patients. Excess length of stay, extra costs, and attributable mortality. JAMA The Journal of the American Medical Association 271, 15981601.

• Raad I., Hanna H.A., Awad A., Alrahwan A., Bivinis C., Khan A., Richardson D., Umphrey J.L., Whimbey E. & Mansour G. (2001) Optimal frequency of changing intravenous administration sets: is it safe to prolong use beyond 72 hours? Infection Control and Hospital Epidemiology 22, 136139.

• Rasero L., Degl'Innocenti M., Mocali M., Alberani F., Boschi S., Giraudi A., Arnauld M.T., Zuccinali R., Paris M.G., Dallara R., Thaer S., Perobelli G., Parfazi S., De Lazzer T. & Peron G. (2000) Comparison of two different time interval protocols for central venous catheter dressing in bone marrow transplant patients: results of a randomized, multicenter study. Haematologica 85, 275279.

• Retsas A. & Nolan M. (1999) Barriers to nurses' use of research: an Australian hospital study. International Journal of Nursing Studies 36, 335343.

• Rickard C., Wallis S.C., Courtney M., Lipman J. & Daley P.J.P. (2002) Intravascular administration sets are accurate and in appropriate condition after 7 days of continuous use. An in vitro study. Journal of Advanced Nursing 37, 330337.

• Stein A.D., Makarawo T.P. & Ahmad M.F.R. (2003) A survey of doctors' and nurses' knowledge, attitudes and compliance with infection control guidelines in Birmingham teaching hospitals. Journal of Hospital Infection 54, 6873.

• Tait A.R., Voepel-Lewis T., Tuttle D.B. & Malviya S. (2000) Compliance with standard guidelines for the prevention of occupational transmission of bloodborne and airborne pathogens: a survey of postanesthesia nursing practice. Journal of Continuing Education in Nursing 31, 3844.

• Veenstra D.L., Saint S., Saha S., Lumley T. & Sullivan S.D. (1999) Efficacy of antiseptic-impregnated central venous catheters in preventing catheter-related bloodstream infection: a meta-analysis. JAMA The Journal of the American Medical Association 281, 261267.

• Warren D.K., Zack J.E., Cox M.J., Cohen M.M. & Fraser V.J. (2003) An educational intervention to prevent catheter-associated bloodstream infections in a nonteaching, community medical center. Critical Care Medicine 31, 19591963.

• White A.H., Khatib R., Riederer K.M. & Flood M. (1997) Respiratory isolation in a teaching hospital with low-to-moderate rate of tuberculosis: compliance with Centers for Disease Control and Prevention guidelines for identifying patients who may have active tuberculosis. American Journal of Infection Control 25, 467470.