

REVIEW

Preventing contamination at the time of central venous catheter insertion: a literature review and recommendations for clinical practice

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Aims and objectives. To evaluate the evidence base and rationale underpinning the various infections control strategies during central venous catheter insertion and to promote discussion about the key, recurring concepts and recommendations in the literature. Logistical and organisational factors relating to central venous catheter insertion are also examined.

Background. Catheter-related bloodstream infections following the insertion of central venous catheters are associated with significant patient mortality and morbidity, prolonged hospital stays and increased economic costs. Limited published literature specifically examines microbial contamination during the peri-insertion process.

Methods. An integrative literature review supervised by a health informatics librarian was undertaken. On the basis of these data, considerations for clinical practice are provided. Retrieved articles were categorised under the following themes: risk of contamination at insertion; clinical and organisational impact of contamination; strategies for reducing contamination; controversies and challenges with decontamination strategies; recommendations for practice and implications for further research and organisational practice.

Results. Specific recommendations for reducing catheter-related bloodstream infections based on recurring themes include the following: reducing microbial burden on skin prior to the central venous catheter insertion; decreasing contact of gloves and insertion equipment with the patient's skin; using specifically trained staff to prepare and maintain a sterile field; and ensuring a sterile technique is adhered to throughout the central venous catheter insertion process. The need for organisational, procedural and clinical practices to support better healthcare outcomes is demonstrated. Highlighting the importance of executive support and regular review of policy and guidelines are necessary to improve patient outcomes.

Conclusions. Preventing infections related to central venous catheters requires the integration of clinical, organisational and workforce factors.

Key words: catheter-related bloodstream infection, central venous catheter insertion, contamination, maximal barrier precautions, skin antisepsis

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Introduction

Catheter-related bloodstream infections (CRBSIs) following insertion of central venous catheters are associated with increased patient mortality and morbidity, prolonged

hospital stays and high costs (Laupland *et al.* 2004, Yacopetti *et al.* 2010). Many CRBSIs are preventable with appropriate risk reduction methods (Pronovost *et al.* 2006). Standards for inserting central venous catheters (CVCs) are constantly evolving as new strategies and evidence about

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risk reduction emerge (Alexandrou *et al.* 2010a,b, O'Grady *et al.* 2011). Optimising skin antisepsis at the time of catheter insertion is considered important in improving health outcomes (Elliot *et al.* 1997, Palmer & Solano 2005). In recent years, there has been an increased emphasis on full barrier precautions when inserting CVCs (Pronovost *et al.* 2006).

The skin, the largest organ of the body, is colonised by at least 182 species of bacteria, of which the origin of eight per cent are totally unknown (Gao *et al.* 2007). Our understanding of the skin's microflora and skin disinfection has come some way since the father of antisepsis, Joseph Lister, successfully applied gauze soaked in carbolic acid to a compound leg fracture of a 11-year-old boy run over by a horse-drawn cart in 1865 (Tan & Tasaki 2007). He then went on to routinely apply carbolic acid to incisions, surgical equipment and the hands of the surgical team. In a review conducted by Edwards *et al.* (2004), we are reminded just how little we know about skin antisepsis. These authors found only six eligible randomised controlled trials evaluating preoperative antiseptics and found insufficient evidence on whether disinfecting patients' skin before surgery reduced surgical site infections after surgery.

Methods

An integrative literature review, using the method of Whitmore and Knafl (2005), was undertaken using the Clinical Information Access Program (CIAP) that searched electronic articles from The Cochrane Library, The Joanna Briggs Institute, Medline, Cumulative Index to Nursing and Allied Health Literature (CINAHL), PubMed and online e-journals. The review articles were limited to English language articles published between 1975 and 2011, those in the English language and studying human subjects. A range of literature was selected, including clinical studies, case reports, reviews, editorials and commentaries. The World Wide Web was also searched using Google Scholar. Key search terms used were 'central venous catheter', 'CVC insertion', 'skin antisepsis', 'skin micro flora', 'infection prevention' and 'catheter-related blood stream infection'. Specialist health informatics librarians supervised the search strategy and assisted with retrieval. These articles were reviewed using a standardised data extraction strategy to identify concepts and principles for preventing skin contamination, together with suggesting some specific procedural techniques. Data were synthesised using the method of a narrative review and thematic analysis was undertaken. In addition, the authors' clinical experience has also been drawn upon based on over 9550 insertions from

2000–2011 by a dedicated Vascular Access Service working in two academic medical institutions (NY & TS).

Results

Findings are summarised under the themes skin antisepsis; risk of contamination at insertion; clinical and organisation impact of contamination: strategies for reducing contamination; controversies and challenges with decontamination strategies; recommendations for practice; and implications for further research and organisational practice. Key findings are summarised in Table 1 at the end of the Results section.

Skin antisepsis

After an insertion site has been selected, the skin should be prepared with a suitable antiseptic to reduce the resident microbial count on the skin. Despite cleaning, the skin's normal resident flora or pathogenic organisms are not completely removed or killed (Altemeier 1983). Hendley and Ashe (1991) found that while most of the common skin antiseptics eradicated coagulase-negative staphylococci from the skin surface, few killed the organisms from the deeper stratum corneum. Karpanen *et al.* (2008) demonstrated that the commonly used 2% chlorhexidine antiseptic solution penetrated poorly into deeper layers.

Maximising microbial kill for the purpose of CVC insertion involves applying 2% chlorhexidine in 70% alcohol with friction and allowing the solution to air-dry. This process is a recurring theme in the literature (Crosby & Mares 2001, Moureau 2003, Digison 2007). This recommendation has been further endorsed by the EPIC (Pratt *et al.* 2007) and CDC guidelines (O'Grady *et al.* 2011). The Association of Preoperative Registered Nurses (2002) released similar recommendations for skin preparation of patients perioperatively. While this article pertains specifically to surgical procedures, the pathogenesis of surgical wound infections and CVC-related infections are similar (Mangram *et al.* 1999).

Hair removal is another consideration in skin preparation prior to invasive procedures (Tanner *et al.* 2007). While alone it is not viewed as an effective measure for infection prevention, hair removal may be employed for other reasons, including the improved application and performance of dressings and the facilitation of their subsequent removal. When dressings are removed, the reduction in discomfort afforded when hair has been clipped prior to the application of adhesive tapes, and dressings should not be underestimated. Clipping hair is preferred to shaving (which can abrade the skin and increase skin infections),

and this is best done immediately prior to a procedure (Ko 1992). Depilatory creams have been shown to be effective (Kjønniksen *et al.* 2002), but also carry the risk of skin irritation and allergy and are not widely used (The Joanna Briggs Institute 2003).

Risk of contamination at insertion

A selected and prepared site for CVC insertion should be covered with either a sterile cloth or other barrier-type drape (Gnass *et al.* 2004). This covering usually has an open 'window' roughly in the centre of the drape, exposing a small area to allow the clinician to gain access to a central vein via a needle through the skin. Typically the catheter is inserted over a guidewire using a Seldinger technique, after which the device is positioned, secured and then dressed. During the course of obtaining access, palpation of the prepared skin occurs as the clinician identifies traditional landmarks, which helps locate the underlying venous anatomy. This palpation may be significant, especially if gaining access is technically difficult. This potentially exposes the gloved hands of the operator to organisms remaining on the skin despite disinfection. It is this palpation when using a traditional landmark technique that might explain why researchers and authors have noted a reduction in CRBSIs when real-time ultrasound is used as the primary tool to locate and access central vessels. Presumably, this results by minimising glove-to-skin contact (Karakitsos *et al.* 2006).

Kocent *et al.* (2002) showed that over half of gloves used during CVC placement were contaminated just prior to handling the catheter. These contaminated gloved hands then proceeded to pick up the CVC to be inserted and potentially transferred organisms onto the catheter in the process. These authors demonstrated that this contamination was eradicated when the gloves of the clinician were rinsed with an alcoholic chlorhexidine solution prior to picking up the catheter and inserting it over the guidewire.

There are other potential sources of catheter contamination at the time of insertion. Palmer and Solano (2005) found 8.2% of 158 guidewires sampled following CVC insertion were positive for micro-organisms. These cultures were subsequently predictive of catheter tip colonisation. Other authors in Europe have used DNA analysis to compare bacteria found on CVC tip cultures to those found on the needle, dilator and guidewire used for insertion (Jeske *et al.* 2003). This thorough, clinically well-controlled study found a very high incidence of contamination in all of the 112 insertion equipment set-ups: guidewire (44.6%), dilator (28.6%) and needle (9.8%). Despite good infection control

practices in the 112 examined insertions, 7 (6% of cases) displayed signs of sepsis within one week. Five of these (71%) were confirmed to be associated with the CVC by matching genetically related isolates found on the CVC tip with the insertion equipment.

Liversley *et al.* (1998) have found that inserting CVCs through a swan sheath (therefore not exposing the CVC to the skin at insertion) reduced CVC tip contamination from 17% (5/30 – standard Seldinger via the skin) to 3% (1/30); $p > 0.05$. Most species were staphylococcus epidermidis, or some other staphylococcus species. Of those patients who had positive CVC tip cultures, a skin insertion site, insertion needle, guidewire or scalpel contamination were demonstrated in all cases. This study included looking at genomic fragments to try to identify the origin of contamination. While the authors were not always able to show convincing links to catheter colonisation and contamination at insertion, they concluded that the data strongly suggested that organisms on the skin impacted onto the CVC distal tip and insertion equipment during catheterisation. Other authors have found that the most likely source of CVC contamination was the patient's skin on insertion, despite the use of an aseptic technique, which included appropriate skin disinfection and antibiotic prophylaxis (Elliot *et al.* 1997). In this study, organisms were still present on the skin of 67% of patients after application of antiseptics.

Other modes of contamination that are possible peri-insertion include, but are not limited to, inadequate equipment set-up, poorly controlled airflow and lengthy exposure of the sterile field to the environment. This is an important consideration in high traffic areas like intensive care units, or indeed any area not specifically designed for procedural work.

Clinical and organisation impact of contamination

The human and financial impact of CRBSI is well described in the literature, suggesting the length of stay is increased by 10–20 days and additional costs ranging from \$US 4000–56,000 per episode (Pittet *et al.* 1994, Orsi *et al.* 2002, Blot *et al.* 2005). Once contamination occurs, it is merely hours before a fibrin sheath develops over the newly inserted device, where the organisms on the catheter surface have the potential to flourish (Ryder 2001).

Strategies for reducing contamination

Creating a sterile field and adhering to maximal barrier precautions by the clinician and assisting staff is thought to be among the key elements in preventing CRBSIs (Raad *et al.* 1994). Most authorities and published guidelines endorse

maximal barrier precautions, stating this strategy is supported by well-designed experimental, clinical or epidemiological studies (O'Grady *et al.* 2011). However, in clinical practice, the universal use of personal protective clothing has been estimated to occur in less than one-third of procedures conducted by American physicians. The key reason for non-adherence was because most physicians did not believe maximal barrier precautions were effective in reducing CRBSIs (Rubinson *et al.* 2005). While most CVC insertions entail the use of a sterile gown and gloves, the sticking point remains with the wearing of disposable hats and masks. Other authors have shown reductions in CVC-related bacteraemia after instituting maximal barrier precaution protocols (Galpern *et al.* 2008). This disconnect between the published literature, executive endorsement and implementation into routine clinical practice is challenging.

Other researchers have looked specifically at individual components of the maximal barrier precaution bundle, although not specifically in relation to CVC insertion and CVC-related infections. The effectiveness of face masks for preventing surgical site infections in clean surgery was not proven in a review undertaken by Lipp and Edwards (2002). Hubble *et al.* (1995) examined bacterial shedding in laminar-flow operating theatres in the United Kingdom. In this highly controlled environment, they found a 22-fold increase in colony-forming units (CFUs) on agar plates when neither hat nor mask was worn; a 15-fold increase when a hat but no mask was worn, and a four-fold increase when a mask but no hat was used. This implies that a mask exerts a greater influence than a hat on reducing contamination. While these findings had little transference to conventional theatres where CFU counts were consistently high (due to air turbulence) and not affected by theatre dress, it does demonstrate the potential for contamination from healthcare workers not wearing a mask and/or hat.

In 1972, Vesley *et al.* (1972) found 50% less glove contamination when operators were working within rooms with laminar-flow air control. They also cited studies during the 1950s and 1970s stating that the glove punctures were commonplace, ranging from 10–100%, primarily amongst surgeons. These findings highlight the importance of a surgical scrub prior to gloving and inserting CVCs. The authors in the previously cited study by Hubble *et al.* (1995) also felt their findings implied that airflow in the rooms where invasive procedures were conducted had greater influence on contamination than did the levels of protective clothing of healthcare workers.

Other variables have been explored in attempts to reduce the risk of CRBSIs. Levy *et al.* (1988) found that by employing an iodophor-impregnated sterile film at the time of CVC

insertion, glove and catheter tip contamination reduced significantly from 83 and 13%, respectively (without adhesive drape), to 0% with the adhesive drape. This data prompted a prospective audit of a convenience sample of 246 CVCs inserted by a single practitioner between 2007 and 2009, which revealed no statistically significant difference between CVC-related infections inserted through either a surgical adhesive sterile drape or standard fenestrated drape ($p = 0.79$), although the rates of infection in both groups were low: one and three in each group of 123 cases, respectively (N. Yacopetti 2009, *Impact of a Surgical Drape at the Time of CVC Insertion*, St. Vincent's Public Hospital, Sydney, unpublished in-house quality project data).

In addressing the findings cited earlier by Jeske *et al.* (2003) which demonstrated nearly half of all guidewires were contaminated during insertion, the application of dry sterile gauze underneath the insertion needle after the guidewire has been passed could reduce infections by minimising guidewire-skin contact.

Pre-procedural bathing or showering has been shown to reduce bloodstream infections (Denton 1991, Bleasdale *et al.* 2007), but Webster and Osborne (2007) in a Cochrane review found no statistically significant reduction in surgical site infections in preoperative bathing or showering regimens with chlorhexidine. More recently, in 2009, three North American articles were published that demonstrated significant reductions in the acquisition of methicillin-resistant *Staphylococcus aureus* (MRSA) and vancomycin-resistant Enterococcus (VRE) in the ICU setting (Climo *et al.* 2009); significant reductions in CRBSIs in a long-term acute care facility (Munoz-Price *et al.* 2009); and significant reductions in positive blood cultures and CRBSIs in a medical ICU (Popovich *et al.* 2009).

Controversies and challenges with decontamination strategies

Evidence-based understanding of antisepsis for CVC insertion remains poorly defined and its application in the clinical setting is not universally adhered to, leading to potential problems around optimum infection control (Rubinson *et al.* 2005). It is likely that provider, patient and system factors influence practice. It is doubtful that we fully appreciate all of the factors influenced by contemporary skin antisepsis and it is possible that current practices either have minimal or sub-optimal effect, are potentially counterproductive or even harmful. For example, we know there are numerous immune cells in the layers of the dermis and epidermis (Weller *et al.* 2008). These specialised cells (Langerhans, dendritic and mast cells, anti-microbial pep-

Table 1 Summary of findings

Theme	Key findings	Sphere of nursing influence
Skin antisepsis	Little high-quality empirical evidence to inform practice 2% Chlorhexidine + 70% alcohol applied with friction and allowed to air-dry maximises microbial kill 67% of patients still have organisms on skin despite application of antiseptics	Clinical
Contamination on insertion	Up to 44.6% of insertion equipment contaminated at insertion with skin organisms Inadequate equipment set up, lengthy exposure of sterile field to the environment Poorly controlled airflow	Clinical
Clinical and organisational impact of contamination	Once contamination occurs, standard treatments often ineffective Increased length of stay from 10–20 days Additional costs ranging from \$US 4000–56,000	Clinical, management, executive
Strategies for reducing contamination	Creation of sterile field/Maximal barrier precautions Surgical scrub Pre-procedural showering/bathing with antiseptic soap Real-time ultrasound-guided catheter placement	Clinical
Controversies and challenges	Evidence base poorly defined Disconnect between theory and practice Shifting paradigms – all factors of contemporary practices remain poorly understood Conflicting results with some strategies, for example, antiseptic washes/adhesive drapes Complex processes with multiple components difficult to control/implement Broadening use of antiseptic solutions and soaps targeting gram-positive organisms may bring about emergence of gram-negative and fungal infections	Research, clinical, management
Recommendations and considerations	Meticulous attention to infection control measures at insertion – sterile technique and maximal barrier precautions throughout. Appropriate environment: ideally low traffic area with laminar air control Experienced inserting clinicians supported with trained staff who can ensure the multiple clinical considerations are addressed with a systematic approach to reduce errors	Clinical, management, executive
Implications for research and organisational practice	Practice, experience and outcomes should be evaluated and findings disseminated Translational research to identify strategies for implementing evidence into practice Ensuring all levels of the healthcare team are aware of expectations, so compliance can be supported with executive endorsement, management follow-through and appropriate clinical implementation	Research, clinical, management, executive

tides, macrophages and lymphocytes) could all have their normally useful function altered by the application of topical antiseptics during skin preparation. In a review by Cogen *et al.* (2008), we are again reminded of the limited research and understanding of skin microflora. This review specifically explores the shifting paradigms in the interpretation of the role skin microbes play in health and disease. The authors draw parallels between the beneficial function of gut flora and that of skin, and how eradicating perceived harmful microbes with antibiotics (or cutaneous antiseptics) can disrupt potentially positive relationships micro-organisms may have with its host. In addition, the skin's surface is normally slightly acidic (approximately pH 6). Together

with sebum, sweat and the horny layer (including intercellular lipids) this contributes to surface conditions that generally discourage microbial proliferation (Gawkrodger 2008). All of these innate and adaptive immune functions of the human skin may be influenced in ways that are not fully appreciated at this stage. Also, as Kleinpell (2010) points out on the on-line professional forum Medscape discussing pre-procedural chlorhexidine bathing, there needs to be long-term monitoring to ensure that decreasing the growth of Gram-positive bacteria such as MRSA and VRE does not promote the growth of Gram-negative bacteria or fungal infections.

There have been reports of allergy and anaphylaxis to chlorhexidine-based products (Snellman & Rantanen 1999,

Beaudouin *et al.* 2004). As such, its unrestricted use may not be without problems, and its clinical effectiveness still needs validation (more so when employed as an agent for pre-procedure bathing or showering).

Recommendations for practice

Any strategy that is complex to implement is likely to be problematic. Adherence to proposed regimens is poor if implementation is difficult. This is particularly true if multiple steps are required or the steps are technically difficult or time-consuming (Lesar *et al.* 2006).

It is important to emphasise that meticulous attention should be paid to the set up of the equipment required for the CVC insertion. Staff involved in the set up and procedure should wash their hands thoroughly before opening equipment and wear a hat and face mask. Sterile sets should only be opened immediately prior to use. Foot traffic and staff movement should be reduced to a minimum within the procedural space. A room with laminar controlled airflow would be ideal, but in practice, this is not always feasible. Ideally, insertions should be carried out in an area specifically set up with all the necessary apparatus (including spare items, resuscitation equipment etc.) to ensure unforeseen events are catered for and any extra or replacement items are readily available. In short, all involved staff need to adhere to maximal barrier precautions and use a sterile technique throughout the insertion procedure and be prepared for contingencies.

The preferred site to place the device should be chosen so that it enables safe insertion and reduces the risk of infection (which usually, but not always excludes the femoral vein). In addition, variables such as the potential risk of thrombosis, patient comfort, convenience, preferences and the type of device to be inserted all need to be taken into account. Once inserted, a catheter needs to be positioned to maximise patient comfort and convenience, infusion flows and dressing integrity. In the ambulatory patient or those able to shower, the catheter should ideally exit the dressing inferiorly, which reduces water soakage into dressings during showering. The ICU or bed-bound patient being sponge-bathed in bed might benefit from catheters positioned superiorly so as to be in the direction of many head-orientated infusion pumps. Removable, stick-on securing devices allow for adjustments as a patient's condition changes. If the initial dressing is correctly applied, it can remain water resistant and undisturbed for days after the insertion, which might improve infectious outcomes.

An informed knowledge of the different types of catheters and dressings available should guide product selection.

Patients known to be at high risk of CRBSIs or those whom catheter dwell times is expected to be greater than 10 days should have vascular access devices placed that incorporate infection reduction technologies, that is, those with an antibiotic or antiseptic coating or cuffed catheters that are tunneled at the time of insertion. The use of a chlorhexidine-impregnated foam disc around the insertion site has also been shown to reduce infections (Crawford *et al.* 2004, Chambers *et al.* 2005).

Although pre-procedural washing with an anti-microbial soap solution demonstrates mixed results (Webster & Osborne 2007), the skin should be thoroughly cleaned with at least regular soap and rinsed with clean running water before CVC insertions. Prior to standard CVC placements, an antimicrobial soap used on the neck, upper chest or arms is advisable, particularly for immune-deficient individuals or those for whom extended CVC dwell times are anticipated. If the intended insertion site is known in advance, patients should be informed about appropriate cleaning (and given any necessary supplies) and asked to refrain from shaving the intended insertion area at least 24 hours prior to the procedure.

People trained in skin disinfection should be employed to ensure appropriate preparation of insertion sites prior to the placement of a CVC (Association of Preoperative Registered Nurses 2002). This includes the preparation of an alternative site should access via the initial site be unsuccessful. If a jugular or subclavian insertion has failed, the contralateral site should not be attempted because of the possible risk of bilateral haematoma formation and airway impairment and/or bilateral pneumothoraces – both potentially life threatening. Clipping of hair with a surgical clipper that does not disturb the integrity of the skin can be employed within two hours of the procedure to facilitate the application and removal of occlusive dressings (Kjønniksen *et al.* 2002).

The skin of the selected sites should be cleaned with either 2% aqueous chlorhexidine, 2% chlorhexidine, 70% isopropyl alcohol or a 10% povidone iodine solution. These solutions should be available in fresh, single-use presentations. The antiseptic should be applied four times (Clinical Excellence Commission 2007) and with enough friction in differing directions to aid in the mechanical removal of skin organisms and debris, but not so vigorously that the skin's integrity is damaged. The solutions should be allowed to air-dry completely prior to the application of drapes and skin palpation. Aqueous-based preparations have longer drying times than alcohol containing solutions. A sterile, fenestrated drape large enough to cover the entire area and prevent contamination of guidewires should then be placed over the prepared site. The fenestration should expose only

disinfected skin, and this exposed area should be kept to an absolute minimum. Consideration needs to be made for the claustrophobic patient, especially when an internal jugular or subclavian site is selected.

The clinician inserting CVCs should aim to systematically develop a sequence of steps that minimises potential contamination and risk for error and complications. Formulation of such a system is cultivated and refined over time and implies that these clinicians have exposure to a certain number of insertion procedures. Taylor and Palagiri (2007) report a greater than 50% reduction in CVC-related complications when the inserting clinician has been involved in more than 50 insertion procedures compared to those with less than 50 catheterisations. Systematic considerations may include the following: commencing with the application of skin antiseptics appropriately with an applicator ensuring the operator's hands are kept well away from the patient's skin; preparing the catheter (priming the lumens with saline, attaching the appropriate injection caps, etc.) and all necessary insertion equipment should then follow while the skin is permitted to air-dry, and the sterile gloves worn by the proceduralist are unlikely to be contaminated; draping should follow after the antiseptics have completely dried. The administration of local anaesthetic and access to the central vein should be done while maximising the skin's integrity. Multiple injections and 'passes' should be avoided. Utilisation of ultrasound guidance is strongly recommended to decrease the amount of passes, minimise direct palpation and reduce mechanical complication of insertion (Bodenham 2006, Karakitsos *et al.* 2006). Caution must be taken to ensure antiseptics are not inadvertently injected into patients (Ishigami *et al.* 2001) and checks built in place to prevent this from happening.

A scout (un-scrubbed assistant) should be readily available to facilitate the proceduralist maintaining a sterile field and technique and so that any patient concerns or requests can be responded to quickly. This availability for reassurance and assistance allays patient anxiety, should not be underestimated or considered optional. Other important duties this person should perform include checking with the inserting clinician that all potentially retainable items are accounted for, for example, guidewires. The confirmed accountability of sharps (needles, blades) ensures their subsequent disposal is complete with minimal risk to staff. Pre-assembled insertion packs can assist in encouraging set practices, facilitating clinical care and expediting set-up times.

Outcomes and experiences should be recorded, analysed and shared both within local institutions and the wider healthcare community (Clinical Excellence Commission, N.S.W. 2010). Reviewing clinical data regularly is part of

quality assurance and development and refinement of clinical practice (Yacopetti *et al.* 2010)

Implications for further research and organisational practice

Data retrieved above underscore the importance of not only undertaking further research to examine methods of skin decontamination, but also translational research initiatives to identify the best strategies for implementing evidence into practice. This review also demonstrates the importance of the environmental factors as well as clinical skills. The busy surrounds of contemporary clinical areas are not always the best setting to ensure the implementation of systematic strategies outlined in this article. Using dedicated spaces and personnel is likely to result in improved patient outcomes. Considering workforce issues, such as competency, experience and procedural volume, are also important concerns (Gopal *et al.* 2006, Alexandrou *et al.* 2010a,b). Involving senior hospital executives and ensuring clinical managers are aware of what is expected of clinicians, so monitoring of compliance is effective can help ensure these goals are achieved.

Conclusion

Providing central venous access is a vital aspect of contemporary health care in both acute and community care. CVC insertions are complex procedures, and to successfully achieve this without contaminating the device on insertion requires the assimilation of multiple factors. The healthcare learning catch phrase 'see one, do one, teach one' is insufficient to address the necessary skills, knowledge and experience required in order for these procedures to be carried out safely and efficiently. While there remain large gaps in quality data found in the published literature, ensuring that appropriately trained staff, techniques, products and conditions are used at the time of CVC insertion represent an important starting point for the delivery of quality health care. Enlisting executive support and regular review of policy and organisational capabilities is necessary to improve patient outcomes.

Relevance to clinical practice

Nurses have historically been closely involved in the insertion of CVCs. With the increasing number of nurse-lead central venous catheter services, this is a timely and important review for nurses. Clinical nurses need to understand the strategies and rationales of these important infection control measures to guide clinical decision-making; nurse managers need to be aware of the implication of these

devices to effectively plan for implementation of care, competencies and surveillance; and nurse executives need to be aware that it is imperative that organisations are taking the published guidelines and expert consensus seriously in order that the healthcare delivered is both safe and effective.

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Contributions

Study design: NY, PMD; data collection and analysis: NY, PMD and manuscript preparation: NY, PD, JB, TRS.

Conflict of interest

Joy Black works as a Clinical Consultant for Mayo Healthcare. No products endorsed in this article are associated with Mayo Healthcare.

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