Cancer Nurses Society of Australia

Central Venous Access Devices: Principles for Nursing Practice and Education

Summary and Recommendations

Cancer Nurses Society of Australia

CnSA

A shared voice A shared vision

For information, contact the Cancer Nurses Society of Australia
by email: info@cnsa.org.au

Disclaimer statement

This document has been developed by the Cancer Nurses Society of Australia Central Venous Access Device Working Party, an expert working party comprising members of the Cancer Nurses Society of Australia (CNSA).

The information in this document is presented by the CNSA for the purposes of disseminating information for the benefit of nurses working in cancer care.

While the CNSA has exercised due care in ensuring the accuracy of the material contained within this document, knowledge is constantly changing and the CNSA does not accept any liability for any injury, loss or damage incurred by use of, or reliance on the information provided within this document. It is the responsibility of the health care practitioner, relying on current evidence and clinical knowledge of the patient to determine the best treatment for an individual patient.

Description of products does not indicate or imply endorsement by CNSA.

CNSA has no financial interest with the manufacturers of any products mentioned in this document.

Writing Group:

Susan Adams
RN, BEd(Adult & Workplace)

Linda Barrett
RN, BHSc(N), MN(Onc)

Susanne Brooks
RN, Onc Cert

Annette Dahler
RN, B App Sc(N), Grad Cert Nsg(Onc), Grad Dip(Community Counselling), Grad Dip(Advanced Nursing Practice)

William Jansens
RN, Onc Cert

Helen Shaw
RN, Dip HSc(N), Onc Cert, BHSc(N), MN(Medical Nursing)

In consultation with:

Sue Berry
RN, Grad Dip(Onc/Pall Care)

Maria Boland
RN, Grad Cert(Onc), Grad Cert(Haematology), Grad Cert BCNS, Grad Dip Br Ca

Kate Cameron
RN, Grad Dip Nsg(Onc), MNSc

Keith Cox
OAM, RN, Onc Cert, NP

Jenny O'Baugh
RN, OCN, Grad Dip Clin Nsg(Onc/Immun), MN

Alayne Reid
RN, OCN, BN, GDNE, MN(Onc), MHSc

Christina Searle
RN, BN, Grad Dip(Onc/PallCare), MNSc

Critical Reviewers:

Rosita van Kuilenberg
RN, MHN, Cert Onc/BMT, Grad Dip Hlth Ed, MRCNA

Professor Margaret O'Connor
OAM, RN, DN, MN, BTheol, FRCNA

Summary and recommendations

Section One: Educational standards for nurses involved in the management of central venous access devices

Registered nurses who work in oncology and haematology require specific education and training to attain the knowledge, assessment skills and technical expertise required to manage the care for patients who have central venous access devices (CVADs) and the device-related complications that patients may experience (Goodman, 2002).

The nursing role includes: assessing the patient's vascular access needs; recommending the appropriate device for treatment (in collaboration with medical staff); educating the patient and the family about the device and its care; providing ongoing CVAD management, including the management of complications and the ability to advocate for the patient when necessary (Chernecky et al. 2003).

Competence implies that the individual possesses the ability to perform in several skills areas including patient and family education, problem solving, application of theory to practice, and psychomotor skills, within a given setting or role (Dool, Roehaver & Fulton, 1993).

Recommendations:

Curricula for CVAD education should include: indications for use; device selection; insertion and maintenance techniques; relevant methods of preventing and managing infections and other complications and patient education (Rosenthal, 2004).

Educational programs that advance knowledge, skill and competence and determine performance levels for registered nurses caring for patients with CVADs should be provided by the health care facility (Dool, Roehaver & Fulton, 1993).

CVAD specific policies and procedures, based on the current evidence, should be implemented and these should include an evaluation and review process (CNSA CVAD working party).

Competence should be assessed by an experienced competent RN, guided by a procedural checklist, within the context of actual practice (Dool, Roehaver & Fulton, 1993).

Access to ongoing education should be provided and periodic assessment of knowledge and skill should be undertaken (Rosenthal, 2004; O'Grady et al. 2002).

Section Two: Characteristics of central venous access devices used in cancer settings

Catheter Tip Location

CVADs are positioned within the central venous circulation, typically in the superior vena cava (SVC) (Mauro, 2003).

Positioning in the SVC should be in the lower third of the vessel (Tropp et al. 2006; O'Grady et al. 2002; National Association of Vascular Access Networks, 1998).

Device Characteristics

Most long-term devices used in the cancer setting are made from silicone or polyurethane. Silicone is a soft, biocompatible material (Mauro, 2003; Weinstein, 2001). Catheters made from silicone provide benefits for the patient as the material reduces the adherence of fibrin to the catheter and offers increased biocompatibility (Camp-Sorrell, 2004). Polyurethane is a stronger, firmer material, which allows the walls of the CVAD to be thinner while still providing the same lumen diameter (Mauro, 2003; Weinstein, 2001). This material does soften following insertion in response to body temperature and offers increased biocompatibility and less adherence of fibrin, when compared to other materials (Doughtery, 2006; Camp-Sorrell, 2004).

CVADs have three basic tip configurations:

1. Open-ended catheters are available as single- or multiple-lumen catheters and can be trimmed to fit the person's anatomy.
2. Valved catheters allow blood to be withdrawn and solutions infused, however when no force is applied to the valve it remains in a closed position, preventing reflux of blood into the catheter (Fox, Roach & Berman, 2002). These catheters cannot be trimmed at the tip.
3. Staggered tip catheters are designed so that simultaneous aspiration and infusion can be performed with limited mixture of drugs and solutions (Rowley & Goldberg, 2005; Mauro, 2003). These catheters cannot be trimmed at the tip.

Catheters can be single or multi-lumen. Multi-lumen catheters have a higher infection rate than single-lumen catheters (Fox, Roach & Berman, 2002).

The length and size of the catheter will influence the ability to infuse solutions. A shorter device with a wide gauge can be used for faster infusion than a longer device (Gabriel et al. 2005).

Categories of CVADs

CVADs are generally classified into two categories:

1. External devices - tunnelled and non-tunnelled catheters
2. Internal devices - implanted ports

1. External Devices

Tunnelled catheters are surgically implanted with a section of the catheter positioned in a subcutaneous tunnel between the entry site to the vein and the skin exit site. A tissue ingrowth cuff, positioned just inside the exit site, inhibits the migration of organisms into the catheter tract by stimulating the growth of surrounding tissue, thus sealing the catheter tract (RNAO, 2004; O'Grady et al. 2002; Mermel et al. 2001).

Non-tunnelled catheters are those where the exit site is directly above entry into the vein. They do not have a subcutaneous tunnel. These catheters can be single- or multiple-lumen. This category includes peripherally inserted central catheters, which are inserted into the central circulation via a peripheral vein and can remain in place for months (Gabriel et al. 2005; RNAO, 2004). Non-tunnelled central catheters for short-term use can be sited using the jugular veins, the subclavian or femoral veins (Hayden & Goodman, 2005).

2. Internal Devices

The implanted port is a long-term CVAD that can remain in place and be functional for years (Camp-Sorrell, 2004). The main feature is that they are totally implanted, with access gained through the skin via a hollow housing/port containing a septum usually produced from self-sealing silicone, connected to a catheter (Camp-Sorrell, 2004).

Section Three: Patient and family caregiver education

Providing patient and family caregiver education about the care of their central access device, the signs and symptoms of complications of the CVAD and who to contact for assistance can improve patient outcomes (Itano & Taoka, 2005).

Recommendations:

Following education, the nurse should assess that the patient and family caregiver can:

- describe the rationale, the risks and the benefits of the device
- demonstrate care of the catheter to a level appropriate for their needs
- list the signs and symptoms of catheter-related complications
- state who to contact if they have concerns and how to contact them

(Itano & Taoka, 2005).

Patient and family caregiver education should be documented in the patient record (Camp–Sorrell, 2004).

Section Four: Caring for a person with a central venous access device: pre-insertion

The nurse has a role to advocate for patients in relation to the selection of a device appropriate for them (RNAO, 2004).

Appropriate selection of vascular access can minimise risk and maximise the benefits for patients undergoing intravenous therapy (Camp-Sorrell, 2004; Galloway, 2002; O'Grady et al. 2002).

The use of an algorithm to facilitate a comprehensive assessment to plan for vascular assess prior to the initiation of therapy can assist patients and health professionals (RNAO, 2004).

Recommendations:

Written consent for the procedure and the sedation (if sedation planned) should be gained following patient education about the procedure (ANZCA, 2005).

The CVAD insertion technique and insertion site with the lowest risk for complications for the anticipated type and duration of therapy should be selected (O'Grady et al. 2002).

A CVAD with the minimum number of ports or lumens essential for the management of the patient should be selected to reduce the risk of complications (O'Grady et al. 2002).

Antimicrobial prophylaxis should not routinely be given before insertion or during use of a CVAD to prevent catheter colonisation or bloodstream infection (O'Grady et al. 2002).

Optimum aseptic technique during catheter insertion (sterile gown, mask, gloves and large drapes) should be implemented (O'Grady et al. 2002; NICE, 2003; RCN, 2003).

The insertion site should be prepared with 2% chlorhexidine gluconate in 70% alcohol and allowed to air dry before skin penetration (O'Grady et al. 2002; RCN, 2003).

Details of the procedure, the device, tip placement and the condition of the patient should be documented in the patient record, following the insertion (CNSA CVAD working party).

Section Five: Caring for a person with a central venous access device: post-insertion

Caring for the patient with a CVAD includes:

- reviewing patient and family caregiver knowledge and understanding regarding the device
- providing information about the device and its care
- promoting patient comfort
- undertaking procedures to reduce the risk of CVAD-related complications and
- assessing for and managing complications if they occur.

Recommendations:

Proper hand hygiene procedures, before, during and after any CVAD manipulations or procedures, must be implemented to reduce the risk of infection (O'Grady et al. 2002).

Impeccable maintenance practices should be implemented to reduce the risk of CVAD-related complications (CNSA CVAD working party).

Verification of catheter tip placement

The anatomical placement of the catheter tip must be documented in the patient record and checked prior to the initiation of any therapy through the device (RNAO, 2005).

Following catheter insertion, radiological examination (e.g. chest X-ray) should be obtained to: verify catheter placement; detect adverse events and retain as a record of placement (Povoski, 2005).

Prior to infusion of any solution, the integrity of the system should by determined by obtaining a blood return, as this confirms that the CVAD is in the venous system (Dougherty, 2006).

Accessing and de-accessing CVADs

CVADs should be accessed using a sterile technique (Tropp et al. 2006; Camp-Sorrell, 2004).

An implanted port must be accessed using a specially designed non-coring needle (Tropp et al. 2006).

If the non-coring needle is to remain in place, it should be covered with a sterile transparent semi-permeable dressing, which should be changed at least every seven days (Tropp et al. 2006).

Solutions

2% chlorhexidine gluconate and 70% alcohol solution should be used for CVAD site and catheter care and allowed to air dry before the application of the dressing (RNAO, 2004).

Organic solvents such as acetone or ether should not be applied (O'Grady et al. 2002).

Antimicrobial ointments should not be used at the catheter insertion site (RNAO, 2005; Camp-Sorrell, 2004; O'Grady et al. 2002).

Injection access caps, administration sets and add-on changes

All administration lines, extension sets and injection access caps used with CVADs should be sterile, luer-lock design (Tropp et al. 2006).

Needleless access to the catheter and safety non-coring port access needles should be implemented to protect health care practitioners from injury (CNSA CVAD working party).

The injection access cap should be changed for a sterile cap each seven days or earlier if compromised by presence of blood or if the integrity of the cap is compromised (MHRA, 2005; RCN, 2005; Perucca, 2001).

Positive fluid displacement injection caps may be used on CVADs to reduce the risk of occlusion (Rummel, Donnelly & Fortenbaugh, 2001).

Administration sets should not be disconnected (and reconnected at a later time) for the purpose of the patient showering or toileting as this may increase the risk of complications such as infection and catheter occlusion (CNSA CVAD working party).

The type of solution administered can alter the frequency of administration set change. More frequent administration set change is required for fluids that enhance microbial growth (O'Grady et al. 2002).

Intravenous administration sets being used for:

- continuous infusions should be changed every 96 hours (Gillies et al. 2005)
- transfusion of blood and fresh or frozen blood products should be changed every eight hours or on completion of administration, whichever occurs first (ANZSBT, 2004).
- infusion of lipids and parenteral nutrition containing lipids should be changed every 24 hours (Gillies et al. 2005; RNAO, 2005)
- parenteral nutrition containing only amino acids and dextrose should be changed every 72 hours (O'Grady et al, 2002)
- fractionated products (IvIG, clotting factors, albumin) should be changed on completion of infusion (RNAO, 2005)
- propofol infusion tubing should be replaced every six or 12 hours, depending on manufacturers' recommendation (O'Grady et al. 2002).

Dressings

Tunnelled catheters that have well healed exit sites and implanted port sites that are well healed and not accessed do not require dressings (RNAO, 2005; O'Grady et al, 2002).

CVADs should be dressed with a sterile dressing, using an aseptic technique (RNAO, 2005; O'Grady et al. 2002).

The dressing should be changed if the integrity of the dressing is compromised and at an interval appropriate for the dressing product used (RNAO, 2005; O'Grady et al. 2002).

The choice of dressing may be made according to the clinical situation, including patient allergies and preference (Gillies et al. 2003; O'Grady et al. 2002).

- Gauze dressings should be changed every 48 hours or earlier if integrity of dressing is compromised (RNAO, 2005)
- Transparent semi-permeable dressings should be changed every seven days or earlier if integrity of dressing is compromised (Camp-Sorrell, 2004; RNAO, 2005; O'Grady et al. 2002)

Instruct the patient to cover the exit site and the external catheter and connecting device with a waterproof cover when showering to reduce the risk of introducing organisms into the catheter or exit site (Camp-Sorrell, 2004; O'Grady et al. 2002).

Flushing

Flushing of CVADs with 10-30mls of 0.9% sterile sodium chloride solution using a "push-pause" positive pressure technique is recommended:

- before and after
    - o administration of medication
    - o administration of blood and blood products
    - o intermittent therapy
- after obtaining blood specimen/s
- when converting from intermittent therapy
- for device maintenance when not in use

(RNAO, 2005).

The minimum size syringe used to access or flush CVADs should be 10ml (RNAO, 2005; Camp-Sorrell, 2004).

Locking the CVAD

There is limited evidence to inform the appropriate solution and the frequency of flushing and locking.

Heparin should be used only when necessary, and in the lowest concentration and volume possible (RNAO, 2005).

The use of 0.9% sterile sodium chloride solution for locking is effective in maintaining the patency of valved CVADs (RNAO, 2005).

A common concentration for locking implanted ports is 50IU Heparin in 5 ml 0.9% sterile sodium chloride solution (CNSA CVAD Working Party).

Routine flushing and locking is recommended for dormant ports (RCN, 2005; Camp-Sorrell, 2004) with a flushing interval of four to six weekly (Camp-Sorrell, 2004).

Securing the CVAD

All CVADs should be secured using a method appropriate for the device to enable assessment and monitoring of the site, and prevent dislodgement, migration and catheter damage (RNAO, 2005).

Removal of a CVAD

The removal of a CVAD should only be performed by an appropriately educated and trained health care practitioner (RCN, 2005).

If the device is being removed due to suspected or confirmed infection, it is recommended the tip be cut off using a sterile procedure and sent for culturing (Dougherty, 2006).

On removal of the CVAD, the health care practitioner should check the catheter's integrity to ensure removal of the entire device (Dougherty, 2006).

New technology

When changing technology, it is recommended that: catheter-related blood stream infection rates are monitored; approved policies are in place; and comprehensive, detailed education and clinical skills training supports the change in practice (Health Devices Alerts, 2006).

Section Six: Complications related to central venous access devices and their management

Recommendations:

Many CVAD-related complications can be limited by:

- inserting the smallest gauge CVAD with the least number of lumens possible for the patient's treatment (O'Grady et al. 2002)
- verifying catheter tip placement in the lower third of the superior vena cava on insertion and routinely over the placement period
- regular and consistent maintenance procedures using strict aseptic techniques (Camp-Sorrell, 2004; Tezak, 2003; Penne, 2002).

The patient and family caregiver should be educated to:

- undertake regular surveillance of their CVAD
- undertake immediate emergency action to minimise risks if a CVAD complication is detected
- report any concerns about the device or their health

(CNSA CVAD working party).

All patient concerns about their CVAD should be investigated (CNSA CVAD working party).

Information relating to a CVAD event, including the cause, action taken and outcomes should be documented in the patient's record (CNSA CVAD working party).

Information relating to CVAD events including incidence, degree, cause, corrective action and outcome should be collected and readily retrievable so that trends and possible causative factors can be identified, rectified and reported (CNSA CVAD working party).

CVAD-related infections

The patient and the family caregiver should be educated to report symptoms of infection, redness, swelling, pain/discomfort or any exudate at the exit or implanted port site (CNSA CVAD working party).

Health care staff should be educated in appropriate infection-control measures to prevent CVAD-related infections (O'Grady et al. 2002).

Appropriate nursing staff levels should be allocated in high acuity patient areas to minimize the incidence of CVAD-related infections (O'Grady et al. 2002).

The number of CVAD manipulations should be limited (Rosenthal, 2004; O'Grady et al. 2002).

Maintenance procedures should include:

- At minimum, daily site assessment, using inspection and light palpation of the exit site (through the dressing), tunnel or port pocket (Camp-Sorrell, 2004). If tenderness/pain, swelling or exudate the dressing should be taken down, using aseptic technique to enable closer inspection (CNSA CVAD working party).
- Documentation of the assessment of exit site or implanted port site daily (Camp-Sorrell, 2004).
- Regular assessment of patient's temperature (CNSA CVAD working party).
- Signs and symptoms of suspected infection should be documented and reported to a medical officer to enable further investigation and implementation of appropriate treatment (CNSA CVAD working party).

Suspected infection should be investigated by:

- exit site swabs if there are signs of localised infection (Camp-Sorrell, 2004).
- blood cultures from all lumens of the CVAD and peripheral blood cultures if there is suspected catheter infection (Camp-Sorrell, 2004; Mermel et al. 2001).

Multiple-lumen catheters should have each lumen used for the administration of the antibiotic during the course of the treatment (Camp-Sorrell, 2004).

Removal of the CVAD should only be done when there is: persistent tunnel infection over a number of weeks; fungal infection; continued infection despite antibiotic therapy; confirmed CVAD sepsis (Camp-Sorrell, 2004; O'Grady et al. 2002) or if there is a risk of progressive infection in a patient who is immunocompromised (Dougherty, 2006).

CVAD occlusions

Line patency on each access, including the observation of blood return and any resistance experienced should be documented to assist in early detection and management (CNSA CVAD working party).

Flushing procedures should be established to reduce the risk of occlusion including: flushing between drugs; flushing with the correct solution, volume and technique and flushing at the correct frequency for the device in use (Dougherty, 2006; Hamilton, 2006; Tezak, 2003).

Fluids should be infused using a pump and a 'to keep vein open' rate should be the least rate of administration to prevent backflow at any time the CVAD is connected (Dougherty, 2006).

CVAD-related thrombosis

The risk of CVAD-related thrombus can be reduced by:

- correct placement of catheter and impeccable maintenance practices (Hamilton, 2006; Kuter, 2004; Knutstad et al. 2003; Mayo, 2001)
- educating patients about the signs and symptoms of thrombosis (i.e. redness, swelling, heat, pain/discomfort in any area along the catheter tract) so they can report problems early (Mayo, 2001)
- monitoring patients with higher risks.

Infiltration and extravasation

The patient should be educated to report any burning or pain on drug infusion (Sauerland et al. 2006).

Before and during administration of drugs, the patency of the CVAD should be assured by checking for blood return and a free flowing infusion (Dougherty, 2006; Sauerland et al. 2006; Buchanan et al. 2005).

Only educated and clinically competent RNs should administer irritant and vesicant drugs (Sauerland et al. 2006).

Each institution should have a policy for the management of drug extravasation (CNSA CVAD working party).

An extravasation should be documented in the patient record, including: the site of the extravasation; the drug; an estimate of the amount of drug extravasated; the access device in use; all actions taken to minimise damage and to provide patient support; and the outcomes for the patient (CNSA CVAD working party).

An extravasation should be reported as an adverse incident, with the possible cause reported, examined and all actions and patient outcomes reported (CNSA CVAD working party).

CVAD-related cardiac complications

Following catheter insertion, radiological verification must be obtained to verify catheter tip placement (Povoski, 2005).

Tip position should be checked radiographically if there are changes in CVAD function, if signs and symptoms of complications are evident or if the catheter has been replaced over a guidewire (RNAO, 2005).

Measure and document the external length of the CVAD on insertion and routinely when suture free devices are in use (CNSA CVAD working party).

There may be some benefit from routine radiological examination of tip location for patients with long term devices (CNSA CVAD working party).

Catheter damage

Educate patients and the family caregivers:

- never to use sharp instruments near their CVAD
- to protect their external devices at all times e.g. during sexual, leisure and sporting activities (CNSA CVAD working party).

CVADs with signs and symptoms of pinch-off syndrome should be assessed for damage (Dougherty, 2006).

CVADs that are damaged due to pinch-off syndrome should be removed (Mirza, Vanek & Kapensky, 2004).

Use a 10ml or greater syringe size on all CVAD lumens (Dougherty 2006; Andris & Krzywda, 1999; Hadaway, 1998).

Do not use excessive force when attempting to flush, unblock or inject into a CVAD (Dougherty, 2006; Hamilton, 2006; Andris & Krzywda, 1999; Hadaway, 1998).

For an external fracture of the catheter:

- educate the patient regarding immediate actions to undertake (CNSA CVAD working party)
    - o immediately clamping the portion of CVAD remaining outside the skin between the site of damage and the chest wall (Dougherty, 2006)
    - o ensuring the CVAD does not migrate into the vein (CNSA CVAD working party)
    - o immediately contacting the health care facility (CNSA CVAD working party).

For an internal fracture of the catheter:

- contact a medical officer
- place the patient on the left side in Trendelenburg position
- apply oxygen
- ensure a chest x-ray is performed urgently to confirm catheter fragmentation and location
- if a PICC breaks during removal, immediately tourniquet the arm and monitor vital signs and pulses in the tourniquet arm

  (Andris & Krzywda, 1999; Hadaway, 1998).

References

American Association of Blood Banks (2000), Standards for Blood Banks and Transfusion Services Vol 19th Ed. California: AABB.

American Association of Blood Banks (2005), AABB Technical Manual (15th Ed). California: AABB.

Andrews CM. (2002), Preventing air embolism: emergency management related to central venous catheterisation. American Journal of Nursing, Vol. 102, No. 1, pp.34-6.

Andris DA and Krzywda EA. (1999), Central venous catheter occlusion: successful management strategies. Medsurg Nursing, Vol. 8, No. 4, pp.229-36.

(The) Australian and New Zealand College of Anaesthetists (2000), Recommendations for the Perioperative Care of Patients Selected for Day Care Surgery. Accessed online 11 February 2007; http://www.medeserv.com.au/anzca/publications/profdocs/profstandards/ps15_2000.htm

Australian and New Zealand College of Anaesthetics (2005) Guidelines for Conscious Sedation for Diagnostic, Interventional Medical and Surgical Procedures. Accessed online : http://www.medeserv.com.au/anzca/pdfdocs/PS9-2005.pdf

Australian and New Zealand Society of Blood Transfusion Inc and Royal College of Nursing Australia (2004), Guidelines for the Administration of Blood Components. Sydney: ANZSBT.

Australian and New Zealand Children's Oncology Haematology Group (2005), Central Venous Access Devices ANZCHOG Nursing Group Working Party Recommendations for Hand Hygiene for all aspects of CVAD management.

Australian Nursing and Midwifery Council (2003), Code of professional conduct for nurses in Australia.

Australian Nursing and Midwifery Council, Royal College of Nursing Australia & Australian Nursing Federation (2002), Code of Ethics for Nurses in Australia.

Australian Nursing Federation (2005), Competency Standards and Nursing – ANF Policy

BARD Access Systems http://www.bardaccess.com/specs-grosh-picc.html Accessed 6th March 2006

BARD Access Systems www.bardaccess.com/pdfs/brochures/bro-hick-bro-leon.pdf Accessed 6th March 2006

BARD Access Systems www.bardaccess.com/pdfs/nursing/ng-hick-leon-brov.pdfs Accessed 6th March 2006

Brazier M. (2000), Flushing Protocols for Central Venous Access Devices: A literature review. Canadian Intravenous Nurses Association Yearbook 2000, 56–60.

British Committee for Standards in Haematology, Blood Transfusion Task Force (1999), The administration of blood and blood components and the management of the transfused patients. Transfusion Med 1999;9:227_38.

Brown S. (2005), Complications with the use of venous access devices. Retrieved from http://www.uspharmacist.com

Bruch HR and Esser M. (October 2003), Catheter occlusion by calcium carbonate during simultaneous infusion of 5-FU and calcium folate. Onkologie, 26(5): 425:6

Buchanan IB; Cambell BT; Peck MD; and Cairns BA. (2005), Chest Wall Necrosis and Death Secondary to Hydrochloric Acid Infusion for Metabolic Alkalosis. Southern Medical Journal. August;98(8):822-824

Camp-Sorrell D. (Ed), (2004), Access device guidelines: recommendations for nursing practice and education (2nd Edition) Oncology Nursing Society: Pittsburgh.

Chaiyakunapruk N; Veenstra DL; Lipsky BA and Saint S. (2002), Chlorhexidine compared with povidone-iodine solution for vascular catheter-site care: a meta-analysis. Annals of Internal Medicine Vol 136, No 11, pp. 792-801.

Chernecky C; Macklin D; Nugent K; and Waller JL. (2003),Preferences in choosing venous access devices by intravenous and oncology nurses. Journal of Vascular Access Devices, 2003, Vol 8, No 1, pp. 35 – 40.

Clough LF. (2002), Venous Access. In Andraejewski C, Golden P, Kong B, Koo A, Smith JW and Zielinski ID (Eds), Arizona: ASPA.

Cowley K. (2004),Make the right choice of vascular access device, Professional Nurse. 2004, Vol 19, No 10, pp. 43-46.

Crosby CT and Mares AK. (2001), Skin antisepsis: past, present, and future. Journal of Vascular Access Devices. Vol 6, No 1, pp. 26-31.

Czepizak CA, O'Callaghan JM, and Venus B. (1995), Evaluation of formulas for optimal positioning of central venous catheters. Chest, 107 (6), 1662-1664.

D'Andrea F. (2004), Surgical treatment of ulcers caused by extravasation of cytotoxic drugs. Scandinavian Journal of Plastic and Reconstructive Surgery and Hand Surgery. Vol. 38, No 5, pp. 288-92.

Denton (2001), Chlorhexidine in Block SS. Disinfection, Sterilization and Preservation, 5th Edition, Chapter 15, pp. 321-36,. Philadelphia: Lippincott Williams & Wilkins.

Donlan R. (2001), Biofilms and device-associated infections. Emerging Infectious Diseases, Vol 7 No 2, pp. 277-281.

Dool J, Roehaver C and Fulton J. (1993) Central Venous Access Devices – Issues for Staff Education and Clinical Competence, in Nursing Clinics of North America, Vol 28, No 4.

Dougherty L. (2006), Central Venous Access Devices Care and Management. Oxford: Blackwell Publishing.

Eakle M and Lange S (n.d.) Power injectors put I.V. lines under pressure. http://www.fda.gov/cdrh/medicaldevicesafety/tipsarticles/nj/1104.pdf accessed 28/ 2/07).

Everts R and Harding H. (2004), Catheter-drawn blood cultures: is withdrawing the heparin lock beneficial? Pathology. Vol. 36, No 2, pp. 170-3

Fackler-Schwalbe I, Schwalbe B, Eppler M, Becker A, Prugl L, Gassel W D, Stoffels D and Sudhoff T. (2004) Occlusion of central venous port catheters after simultaneous 24h infusions of 5-FU and calcium folinic acid in patients with gastrointestinal cancer. Wien Med Wochenshr. Vol 154, No (9-10) pp.182-5

Foo KF, Michael M, Toner G and Zalcberg J. (2003), A case report of oxaliplatin extravasation (letter) Annals of Oncology. Vol 14, pp. 961-2.

Fox K, Roach DJ and Berman SS. (2002), Central venous catheters: selection and placement techniques (Chapter 14) In Berman SS. Vascular Access in Clinical Practice. New York: Marcel Dekker, Inc.

Gabriel J, Bravery K, Doughtery L, Kayley J, Malster M and Scales K. (2005), Vascular Access: indications and implications for patient care. Nursing Standard 2005, Vol 9, No 26, pp.45–52.

Galloway M. (2002), Using benchmarking data to determine vascular access device selection. Journal of Infusion Nursing Vol 25, No 5, pp. 320–5.

Garden A and Laussen PC. (2004), An unending supply of 'unusual' complications from central venous catheters. Pediatric Anesthesia, Vol 14, pp. 905-909.

Garland JS, Hendrickson K and Maki DG. (2002), The 2002 Hospital Infection Control Practices Advisory Committee Centres for Disease Control and Prevention Guideline for Prevention of Intravascular Device–Related Infection. Pediatrics. Nov 2002, Vol 110, No 5, Health Module p. 1009.

Gillies D, O'Rhiordan L, Wallen, M, Morrison A, Rankin K and Nagy S. (2005), Optimal timing for intravenous set replacement. The Cochrane Library, The Cochrane Collaboration, 2005, Volume 1.

Gillies D, O'Riordan I, Carr D, Frost J, Gunning R & O'Brien I. (2003), Gauze and tape and transparent polyurethane dressings for central venous catheters. The Cochrane Library, The Cochrane Collaboration, 2003, Volume 3.

Goodman M. (2002), Principles of Chemotherapy Administration: Vascular Access Devices, CancerSource RN.com sourced from Cancer Nursing: Principles and Practice 5th ed.

Gorski LA. (2003), Central venous access device occlusions: part 1 thrombotic causes and treatment. Home Healthcare Nurse, Vol 21, No 2, pp. 115-121.

Grant J. (2002), Recognition, prevention and treatment of home totals parenteral nutrition central venous access complications. Journal of Parenteral Enteral Nutrition, Vol 26 (sup) S21-S28

Hachem R and Raad I. (2002), Prevention and management of long-term catheter related infections in cancer patients. Cancer Investigation Vol 20, (7-8), pp. 1105-1113.

Hadaway LC. (1998), Major thrombotic and nonthrombotic complications: loss of patency. Journal of Intravenous Nursing, Vol 21, No 5S, S143-S160.

Hadaway LC. (2002), Air embolus. Nursing, Vol 32, No 10, p. 104.

Hadaway LC. (2004), Preventing extravasation from a central line. Nursing, Vol 34, No 6, pp. 22-23.

Hadaway LC. (2006),Technology of Flushing Vascular Access Devices. Journal of Infusion Nursing Vol 29, No 3, pp. 137-45.

Hamilton H. (2006), Complications associated with venous access devices: part two. Nursing Standard, Vol 20, No 27, pp. 59 -66.

Hamilton H. (2004), Make the right choice of vascular access device. Professional Nurse, Vol 19, No10, pp. 43-6.

Hanh U, Goldschmidt H, Salwender H, Haas R and Hunstein W. (1995), Large-bore central venous catheters for the collection of peripheral blood stem cells. Journal of Clinical Apheresis, 1995, Vol 10, pp 12-6.

Hayden K and Goodman M. (2005), Chemotherapy: Principles of administration. In Yarbro CH, Frogge MR and Goodman M. (Eds) Cancer nursing: Principles and practice (6th Edition) Boston: Jones and Bartlett.

Health Devices Alerts (2006), Increased Infection Rates with Positive-Fluid-Displacement Luer-Activated Devices. Health Devices Alerts. Vol 30, No 33, pp. 1-3.

Hebden J. (2002), Preventing intravascular catheter-related bloodstream infections in the critical care setting. AACN Clinical Issues, Vol 13, No 3, pp. 373-81.

Itano JK and Taoka KN. (2005), Core Curriculum for Oncology Nursing 4th Ed, Oncology Nurses Society, Elsevier Saunders: St Louise

Jacobs BR, Schilling S, Doellman D, Hutchinson N, Richey M and Nelson S. (2004), Central venous catheter occlusion: a prospective, controlled trial examining the impact of a positive-pressure valve device. Journal of Parenteral and Enteral Nutrition. Vol 28, No 2, pp. 113-8.

Kapadia S, Parakh R, Grover T and Yadav A. (2005), Catheter fracture and cardiac migration of a totally implatnted venous device. Indian Journal of Cancer Vol 42, No 3, pp. 155-7.

Karamanoglu A. (2003), Port needles: do they need to be removed as frequently in infusional chemotherapy? Journal of Infusion Nursing: The Official Publication of the Infusion Nurses Society. Jul-Aug; Vol. 26, No 4, pp. 239-42.

Knutstad K, Hager B and Hauser M. (2003), Radiologic diagnosis and management of complications related to central venous access. ACTA Radiologica, Vol 44, pp. 508-16.

Kretzschmar A, Pink D, Thus-Patience P, Dorken B, Reichart P and Eckert R. (2003), Extravasation of oxaliplatin. Journal of Clinical Oncology , Vol 15, pp. 237-9.

Krzywda EA. (1999), Predisposing factors, prevention, and management of central venous catheter occlusions. Journal of Intravenous Nursing, Vol 22, No 6S, S11-S17.

Kuo YS, Schwartz B, Santiago J, Anderson PS, Fields AL and Goldberg GL. (2005), How often should a port-a-cath be flushed? Cancer Invest, Vol 23, No 7, pp. 582-5.

Kuter D. (2004), Thrombotic complications of central venous catheters in cancer patients. The Oncologist, Vol 9, pp. 207-16.

Lyon SM. (2005), Vascular access devices and the oncology patient, Cancer Forum 2005, Vol 29, No 3, pp. 140–4.

McCance KL and Huether SE. (2002), Pathophysiology The biological basis for disease in adults and children (4th edition). Mosby: St Louis.

McKnight S. (2004), Nurse's guide to understanding and treating thrombotic occlusions of central venous access devices. Medsurg Nursing, Vol 13, No 6, pp. 337-82.

Macklin D and Chernecky C. (2004), Real World Nursing Survival Guide: IV Therapy. Saunders: St Louis.

Macklin D, Chernecky C, Nugent K and Waller J. (2003), A collaborative approach to improving patient care associated with vascular access devices. Journal of Vascular Access Devices. Summer, pp. 8– 13.

Maki DG and Mermel LA. (1998), 'Infections due to infusion therapy'. In Bennett JV & Brachman PS (Eds).Hospital infections. 4th Edition. Philadelphia: Lippincott-Raven.

Maragakis L, Bradley K, Xiaoyan S, Beers C, Miller M, Cosgrove S and Perl T. (2006), Increased Catheter-Related Bloodstream Infection Rates After the Introduction of a New Mechanical Valve Intravenous Access Port. Infection Control and Hospital Epidemiology. Vol 27, No 1, pp. 67-70.

Masoorli, S. (1999). Air embolism. RN, Vol 62, No 11, pp. 32-35.

Mauro MA. (2003), Central venous catheters: materials designs and selection In Pieters PC, Tisnado J and Mauro MA. (Eds) Venous Catheters: A practical manual. New York: Thieme.

Mayo D. (2001), Catheter-related thrombosis. Journal of Intravenous Nursing, Vol 24, No 3S, S13-S22

McDiarmid S, Bredeson C and Huebsch L. (1999), Selection of appropriate venous access for the collection of peripheral blood progenitor cells by experienced apheresis nurses, Journal of Clinical Apheresis, Vol 14, pp. 51-6.

Mehall JR, Saltzman DA, Jackson RJ, and Smith SD. (2002), Fibrin sheath enhances central venous catheter infection. Critical Care Medicine, Vol 30, No 4, pp. 908-12.

Menyhay SZ and Maki DG. (2006), Disinfection of needleless catheter connectors and access ports with alcohol may not prevent microbial entry: the promise of a novel antiseptic barrier cap. Infection Control Hospital Epidemiology, Vol 27, No 1, pp. 23-7.

Mermel LA, Farr BM, Sherertz RJ, Raad II, O'Grady N, Harris JS and Craven DE. (2001), Guidelines for the management of intravascular catheter-related infections, Journal of Intravenous Nursing 2001; Vol 24, No 3, pp.180-205.

MHRA 2005 Medical Device Alert on all brands of needle free intravascular connectors, MDA/2005/030, issued 17 May 2005, London.

Mirza B, Vanek VW and Kupensky DT. (2004), Pinch off syndrome: Case report and collective review of the literature. The American Surgeon Vol 70, pp. 635-44.

National Association of Vascular Access Networks Position Statement, Journal of Vascular Access Devices 1998; Vol 3, pp 8-10.

National Institute for Clinical Excellence (NICE) (2003), Infection control: prevention of healthcare associated infection in primary and community care, Clinical Guidelines 2. Department of Health: London.

New South Wales Department of Health Guidelines, Policy Directive Non-Coring Needles - De-Accessing from Internal Catheter Ports (The) Doc No. PD2005_088 accessed 16th May 2006: http://www.health.nsw.gov.au/policies/PD/2005/PD2005_088.html

O'Grady N, Alexander M, Dellinger EP, Gerberding JL, Heard SO, Maki DG, Masur H, McCormick RD, Mermel LA, Pearson ML, Raad II, Randolf A and Weinstein RA. (2002), Guidelines for the prevention of intravascular catheter-related infections. Centres for Disease Control and Prevention, Morbidity and Mortality Recommendations Report, 2002, August Vol 9, No 51, (RR – 10), pp. 1-29.

Odum L and Drenk NE. (2004), Blood sampling for biochemical analysis from central venous catheters: minimising the volume of discard blood. Clin Chem Lab Med. Feb, Vol 40, No 2, pp.152-5.

Owen HG and Brecher ME. (1997) Management of the Therapeutic Apheresis Patient (Chapter 13) In Mc Leod BC, Price TH and Drew MJ (Eds), Apheresis: Principles and Practice. Bethesda: AABB Press.

Passannante A and Macik BG. (1998), Case report: the heparin flush syndrome: a cause of iatrogenic haemorrhage. American Journal of Medical Science Vol 296. pp 71-3.

Pellowe CM, Pratt RJ, Loveday HP, Harper P, Robinson N. and Jones SRLJ. (2004), The epic project. Updating the evidence-base for national evidence-based guidelines for preventing healthcare associated infections in NHS hospitals in England: a report with recommendations. British Journal of Infection Control. Vol 5, No 6, pp.10-6.

Penne K. (2002), Using evidence in central catheter care, Seminars in oncology nursing Vol 18, No1, pp. 66-70.

Perdue MB. (2001), Intravenous complications. In:Carlson K; Perdue MB and Hawkins J (Eds) Infusion therapy in clinical practice, 2nd edition, WB Saunders: Pennsylvania.

Perucca R. (2001), 'Obtaining vascular access'. In Infusion Therapy in Clinical Practice. 2nd ed. Pennsylvania: WB Saunders, Chapter 20, pp. 338–97.

Polovich M, White J and Kelleher L. (Eds) (2005), Chemotherapy and biotherapy guidelines and recommendations for practice (2nd Ed). Oncology Nursines Society: Pittsburgh.

Povoski SP. (2005), Long-term venous access, In PazdurR; Hoskins W; Coia L; Wagman L. Cancer Management: A multidisciplinary approach (9th edition). CMP Medica: New York.

Primhak RH, Gathercole N and Reiter H. (1998), Letters to the editor: Pressures used to flush central venous catheter. Archives of disease in childhood - Fetal Neonatal Edition. Vol 78, pp. 234.

Queensland Nursing Council. (2005), Scope of Practice Framework for Nurses and Midwives (pp 22). accessed online 22 March, 2007, http://www.qnc.qld.gov.au/upload/pdfs/qnc_policies/Scope_of_practice_framework_for_nurses_and_midwives_2005.pdf

Ralf E, Gebhard MD, Evan G, Pivalizza MD, Jeff L, Cerny MD, Vladimir Melnikov MD, Robert D and Warters MD. (2006), Accuracy of Certofix® Central Venous Catheter Placement Utilizing ECG-Guided Positioning with the Certodyn® Universal Adapter. ABSTRACT: American Society of Anesthesiologists. Annual Meeting Abstracts, 14-18 October, accessed online 8 June, 2006: http://www.asaabstracts.com/strands/asaabstracts/abstract.htm;jsessionid=B23D7A3BED97AF933C0284E472E6FDBE?year=2003&index=14&absnum=622

Ray CE. (1999), Infection control principles and practices in the care and management of central venous access devices. Journal of Intravenous nursing, Vol 22, No 65, S18 – S25.

Registered Nurses Association of Ontario, (RNAO). (2004), Assessment and device selection for vascular access. Toronto: Registered Nurses Association of Ontario

Registered Nurses' Association of Ontario, (RNAO). (2005), Care and Maintenance to Reduce Vascular Access Complications. Toronto, Canada Registered Nurses' Association of Ontario, Accessed March 06. Online: http://www.rnao.org/bestpractices/PDF/BPG_Reduce_Vascular_Access_Complications.pdf

Roberts B and Cheung D. (1998), Biopatch - a new concept in antimicrobial dressings for invasive devices. Australian Critical Care Vol 11, No 1, pp. 6-9.

Rosenthal K. (2004), Guarding against vascular site infection. OR Insider. Vol November 2004, pp. 4–9.

Rosenthal K. (2006), Navigating safely through a minefield of CVAD complications. IV essentials Vol 1, pp. 56-58.

Rowley SD, Hsu JW and Goldberg SL. (2005), Apheresis Technology (Chapter 146) In Hoffman: Haematology: Basic Principles and Practice, (4th Edition). http://home.mdconsult.com/das/book/body/446877238/1267/1336.html?printing=true

Royal College of Nursing Intravenous Therapy Forum. (2003), Standards for Infusion Therapy. Royal College of Nursing: London.

Rummel MA, Donnelly PJ and Fortenbaugh CC. (2001), Clinical Evaluation of a Positive Pressure Device to Prevent Central Venous Catheter Occlusion: Results of a Pilot Study. Journal of Clinical Oncology Nursing, Vol 5, No. 6, pp. 261-5.

Ryder MA. (1993), Peripherally inserted central venous catheters. Nursing Clinics of North America, Vol. 28, pp. 937-71.

Sahlsten MJM, Larsson IE, Plos KAE and Lindencrona CSC. (2005), Hindrance for patient participation in nursing care. Scandinavian Journal of Caring Sciences, 19, pp. 223 – 9.

Sauerland C, Engelking C, Wickham R & Corbi D. (2006), Vesicant extravasation part I: Mechanisms, pathogenesis and nursing care to reduce risk. Oncology Nursing Forum. Vol 33, No 6, pp. 1134-41.

Schuster M, Nave H, Piepenbrock S, Pabst R, and Panning B. (2000), The carina as a landmark in central venous catheter placement. British Journal of Anaesthesia, 2000, Vol 85, No 2, pp. 192-4.

Schulmeister L and Camp-Sorrell D. (2000), Chemotherapy extravasation from implanted ports. CINA Official journal of the Canadian Intravenous Nurses Association Vol 16, Sept, pp. 74-8, 80.

Seymour VM, Dhallu TS and Moss HA. (2000), A prospective clinical study to investigate to investigate the microbial contamination of a needleless connector. Journal of Hospital Infection 2000, Vol 45, pp. 165.

Sheilds LB, Hunsaker DM and Hunsaker JC. (2003), Iatrogenic catrheter-related cardiac tamponade: a case report. Journal of Forensic Sciences. Vol 48, No 2, pp. 414-8.

Schummer W, Schummer C, Schelenz C, Schmidt P, Frober R and Huttemann E. (2005), Modified ECG-guidance for optimal central venous catheter tip positioning. A transesophageal echocardiography controlled study. Anaesthesist. 2005 Oct; Vol 54, No 10, pp. 983-90.

Seymour V, Dhallu S, Moss H, Tebbs S and Elliot T. (2000), A prospective clinical study to investigate the microbial contamination of a needleless connector. Journal of Hospital Infection Vol 45, No 2, pp. 165-8.

Stegmayr B and Wikdahl AM. (2003), Access in Therapeutic Apheresis, Therapeutic Apheresis and Dialysis Vol 2, No 7, pp. 209 -14.

Steiger E. (2006), Dysfunction and thrombotic complications of vascular access devices. Journal of Parenteral and Enteral Nutrition. Vol 30, No 1, S70-S72.

Stephens LC, Haire WD, Kotulak GD, Schmit-Pokorny K and Kessinger A. (1995),Double lumen subclavian apheresis catheters for peripheral stem cell collection: high incidence of thrombotic occlusion. Journal of Clinical Apheresis 1995, Vol 10 pp. 52–7.

Tezak B. (2003),Leading Change: Validating central line practices with research. CINA: Official journal of the Canadian Intravenous Nurses Association, 2003; Vol 19, pp. 34-7.

Todd J. (1998),Peripherally inserted central catheters, Professional Nurse. 1998, Vol 13, No 5 pp. 297-302.

Tripepi-Bova KA, Woods KD and Loach MC. (1997), A comparison of transparent polyurethane and dry gauze dressings for peripheral IV catheter sites: rates of phlebitis, infiltration, and dislodgment by patients. American Journal of Critical Care. Vol 6, No 5, pp. 377-81.

Tropp J, Bagnall-Reeb H, Gorski L, Hadaway L, Hunter M, Roth D and Saxton J. (2006), Infusion Nursing Standards of Practice, in Journal of Infusion Nursing Vol 29, No 15.

Van de Wetering MD and van Woensel JBM. (2003), Prophylactic antibiotics for preventing early central venous catheter gram positive infections in oncology patients. The Cochrane Database of Systematic Reviews, 2003, Issue 1.

Vardy J, Engelhardt K, Cox K, Jacquet J, McDade A, Boyer M, Beale P, Stockler M, Loneragan R, Dennien B, Waugh R and Clarke SJ. (1997), Long-term outcome of radiological-guided insertion of implanted central venous access port devices (CVAPD) for the delivery of chemotherapy in cancer patients: institutional experience and review of the literature. British Journal Of Cancer Sep 13; Vol 91, No 6, pp.1045-9.

Webster J and Osborne S. (2005), Preoperative bathing or showering with skin antiseptic to reduce surgical site infection Cochrane database of systematic reviews: John Wiley and Sons: http://eprints.qut.edu.au/archive/00003803/01/3803.pdf accessed 11 February 2007).

Weinstein SM. (2001), Principles and Practice of Intravenous Therapy. (7th Edition) Philadelphia: Lippincott.

Wickham R, Engelking C, Sauerland C and Corbi D. (2006), Vesicant extravasation part II: Evidence-based management and controversies, Oncology Nursing Forum. Vol 33, No 6, pp. 1143-50.