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Guideline

BCSH GUIDELINES ON THE INSERTION AND MANAGEMENT OF CENTRAL VENOUS LINES

These guidelines are a review of basic principles and relevant research for nursing and medical staff involved in the care of patients with skin-tunnelled catheters. They complement existing guidelines for nursing staff (Royal College of Nursing, 1995). The guidelines are not intended as a substitute for local policies and protocols but should provide a useful source of reference for those writing such documents. Non-tunnelled lines and dialysis lines are not discussed, but some reference is made to peripherally inserted central catheters (PICC lines).

Major recommendations

1. Tunnelled central venous lines (catheters) are indicated for the repeated administration of chemotherapy, antibiotics, parenteral feeding and blood products, and for frequent blood sampling.

2. Single lumen catheters are to be preferred as they cause fewer problems, but multiple lumen catheters have specific indications.

3. Fully implantable catheters (ports) are more suitable for children and for less frequent but long-term use, whereas non-fully-implantable lines are better for short-term use and intensive access.

4. Insertion should be performed by experienced operators, regardless of specialty. Lines should be inserted in children by paediatric specialists.

5. Imaging facilities (fluoroscopy, intravenous contrast studies and standard radiography) must be available.

6. Line insertion should take place in an operating theatre or similar clean environment.

7. Skin cleansing is of the utmost importance.

8. Routine antibiotic prophylaxis should not be used.

9. Dressings are not required in the long term but regular flushing (by protocol according to the type of line) is essential to prevent thrombosis.

10. Pre-existing haemorrhagic, thrombotic or infective problems must be effectively managed before line insertion.

11. Thrombosis and infection must be promptly diagnosed and vigorously treated. Both complications may require removal of the line.

12. Catheters should be removed only by experienced personnel. Catheter breakage requires expert radiological intervention.

13. Patients should receive clear and comprehensive verbal and written information and be encouraged to look after their own lines.

14. Units should audit complications associated with central lines and use the data to develop preventative measures.

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1. *Indications for catheter insertion*

These catheters are indicated (a) when venous access is poor, (b) when embarking on prolonged intravenous chemotherapy and/or total parenteral nutrition (TPN), or for repeated administration of blood products, etc., (c) when intravenous therapy involves drugs known to be venous sclerosants, and (d) when ambulatory chemotherapy is to be given as an out-patient.

2. *Choice of catheter*

Catheters are divided into (a) tunnelled fully implantable and (b) non-fully implantable devices. They may have single or multiple lumina. Multiple lumen catheters are advantageous in patients undergoing bone marrow transplantation or high-dose chemotherapy where a number of agents and blood products require to be infused simultaneously. Multiple lumen catheters are more expensive and associated with increased morbidity (Henriques *et al*, 1993) so that they should be used only when indicated.

Catheters are made of either silicon rubber or polyurethane, the former being associated with a lower risk of thrombosis and the latter providing a larger lumen for the same outer diameter of the line. Non-fully implantable lines have a Dacron cuff which induces an inflammatory reaction leading to fibrosis. Fixation of the catheter usually occurs within 3–4 weeks of insertion. The Dacron cuff does not prevent infection, but lines with additional anti-microbial cuffs are available.

The four commercially available types of catheter are summarized in Table I. It is important to choose the appropriate luminal size of catheter for the patient and the proposed application.

Table I. Tunnelled central venous lines: catheters available.

Catheter	Type	Advantages	Disadvantages	Cost of catheter	Cost of maintenance
Hickman (Bard) and Hickman-like (e.g. Cook, Vygon)	End hole, not fully implantable (NFI)	Readily available Widespread experience of use	Need regular flushing using heparin Interference with activities Higher risk of infection	Low	High
Groshong	Side hole, with valve, NFI	Radio-opaque tip Less frequent flushing without need for heparin Valve makes bleeding or air embolism less likely Smaller than Hickman lines for same flow rate Easier to insert percutaneously (dedicated insertion kit)	As for Hickman Unsuitable for collection of PBSC	Medium	High
Apheresis	End or side hole, large bore, NFI	Permits high blood flows, e.g. for PBSC collection	As for Hickman Limited line survival Requires high doses of heparin Uncomfortable for patient	Medium	High, but usually short term
Subcutaneous port	Fully implantable	Less risk of displacement Less interference with activities Reduced risk of infection Infrequent flushing More suitable for long-term use	Not suitable for frequent repeated access Requires special needles Infection worse if it occurs	High	Low

3. *Insertion of catheter*

We recommend that catheters are inserted only by experienced personnel. The procedure should be performed in a clean area, e.g. X-ray department, operating theatre or cardiac catheterization suite where a high standard of asepsis is practised. Units which currently insert central venous lines on the wards should audit their infection rates in order to support continuation of this practice. Published evidence shows, however, that the risk of infection depends mainly on the presence of bacteria on the skin (Campbell *et al*, 1994).

In the operating theatre a mobile image intensifier can be used to provide imaging guidance; the appropriate radiological safety precautions must be taken, including the wearing of lead aprons. Normally a line is inserted under local anaesthesia with sedation such as intravenous midazolam. This is not appropriate for children, who will require a general anaesthetic. Open insertion in adults is also better performed under general anaesthesia, first attempting to insert the catheter into the external jugular and then if unsuccessful into the main jugular vein.

There are two general types of tunnelled central venous catheter: antegrade or retrograde tunnelled lines. Antegrade tunnelled catheters must be measured and cut to the correct length, leaving as smooth a tip as possible. This is best done using fluoroscopic guidance and works well in most patients. With retrograde tunnelling the tip of the catheter is positioned under fluoroscopy and should be above the right atrium. The catheter is then tunnelled retrogradely before the hub is fixed on to its proximal end. Tunnelling may not reduce the rate of infection but minimizes the risk of accidental displacement.

Lines are increasingly inserted percutaneously and the optimum method is by the use of imaging guidance under local anaesthesia and sedation. Anatomical surface markings can be unreliable for the initial puncture and both ultrasound and venography via the antecubital vein may be helpful. These techniques also establish the patency of the veins. A lateral insertion site reduces the risk of pneumothorax and avoids 'pinch off' of the catheter between the clavicle and the first rib (Robertson *et al*, 1989). An alternative is to use the jugular vein; this is a rapid, straightforward procedure, which is particularly useful in patients with abnormal coagulation, as it minimizes the risk of inadvertent arterial puncture (Lameris *et al*, 1990). In patients in whom the internal jugular and both subclavian veins are occluded or otherwise unavailable for puncture,

catheters may be inserted into the femoral veins, hepatic veins or directly into the inferior vena cava (IVC) using an interventional radiological technique. These techniques must only be performed by experienced radiologists, and ECG monitoring is required when lines are advanced into the IVC as there is a significant incidence of dysrhythmia.

A variety of catheter puncture kits can be used. It is recommended that a coaxial catheter introduction system is used with a 20 or 21 guage needle for the initial puncture. 25 guage micropuncture sets are also available and are useful for children, minimizing the risk of bleeding in patients with abnormal coagulation and the need for intervention if the pleura are punctured.

With subcutaneous ports, subclavian venous access is achieved under aseptic conditions, in the same way as for externalized tunnelled lines (Sherry *et al*, 1992). A suitable site for the port is chosen in the chest wall, in a position in which it may be accessed by the patient. It is important to provide a bony support for the port during access, allow for a short but gently curved path from the reservoir to the site of venous access and avoid mammary tissue.

Peripherally inserted central catheters (PICC lines) require less in the way of facilities or operator experience and may be inserted in a side room on the ward by nursing staff (Roundtree, 1991). Tip placement should be checked by X-ray and often requires adjustment. The role of these lines in the U.K. remains to be established. The subject has been reviewed by Braun (1994).

4. *Patient care prior to catheter insertion*

Skin cleansing is the most important part of care before line insertion. Chlorhexidine is the most effective agent (Maki *et al*, 1991). If povidone iodine is to be used (assuming the patient is not allergic), the skin should be cleaned for 3 min and the iodine allowed to dry. Depilation may be necessary but shaving of the chest wall should not be performed. Patients should ideally shower with Hibiscrub prior to line insertion and wash their hair with chlorhexidine to reduce staphylococcal burden.

5. *Antibiotic prophylaxis*

Various published studies have produced conflicting results as to the value of prophylaxis in non-neutropenic cancer and non-cancer patients requiring a central venous catheter for intravenous treatments. There are a number of prospective randomized trials examining the use of either vancomycin or teicoplanin in adults and children undergoing treatment for haematological and non-haematological malignancies (Ranson *et al*, 1990; Vassilomanolakis *et al*, 1995; Schwartz *et al*, 1990; Schaison & Decroly, 1991; Lim *et al*, 1993).

The majority of Gram-positive infections preventable by glycopeptide prophylaxis are due to coagulase negative staphylococci. Although these cause a considerable amount of morbidity, they are rarely associated with mortality and are amenable to therapy. The inexorable spread of vancomycin-resistant enterococci, which cause significant infections in cancer patients (Montecalvo *et al*, 1994; Edmond *et al*, 1995; Noskin *et al*, 1995) and which are being increasingly isolated in the U.K. (Anonymous, 1995), are causing many to rethink their use of glycopeptides. The Centers for Disease Control and Prevention (1994) have issued guidelines for limiting the use of vancomycin, stating that the agent should not be used for routine prophylaxis, i.v. colonization, catheter-related infections with beta-lactam-sensitive organisms or empirical therapy of febrile neutropenic patients.

The overall balance is therefore against the routine use of a glycopeptide as prophylaxis for catheter insertion, certainly in non-neutropenic patients. The data on patients neutropenic at the time of catheter insertion is clinically of greater importance but, inevitably, more scanty. If the patient is severely neutropenic (WBC $< 0{\cdot}5 \times 10^9$/l) and likely to bleed during the procedure then anecdotal evidence suggests a high risk of infection. Studies of the benefits of prophylaxis in this setting are urgently needed. Recent work suggests that loading of catheters with a silver–teicoplanin complex during manufacture may reduce adherence of micro-organisms and prevent colonization (Jansen *et al*, 1994).

6. *Immediate patient care post catheter insertion*

After the procedure, the wounds should be dressed; once blood stained, dressings should be changed immediately. Because of the 1–2% incidence of traumatic pneumothorax post operatively (Ray *et al*, 1996), a chest X-ray is required if the patient becomes dyspnoeic. The incidence of pneumothorax relates to the site used for line insertion into the subclavian vein. Most pneumothoraces do not require treatment but should be monitored. Needle evacuation is often sufficient when treatment is required, and formal chest drainage is rarely indicated.

Occlusive dressings should be avoided, and it is better to use a porous adhesive dressing such as Tegaderm (3M Healthcare Products, U.S.A.) or a semi-occlusive dressing such as OpSite IV3000 (Smith & Nephew, U.K.). The latter should be changed weekly. Other dressings should be changed daily until the wound is healed, after which no dressing is required but the catheter should be looped and fixed to the skin.

The upper suture over the insertion site into the subclavian vein may be removed at 7–10 d and the lower one at the exit point may be removed after 3 weeks. This, however, may remain long term if there is any concern regarding the line falling out spontaneously. Subcuticular proline does not need to be removed and ensures that the line remains in place. Sutures over a Portacath insertion site are removed at 7–10 d.

With the Groshong catheter the line may be glued to a retaining cassette sutured to the skin. The glue takes 24 h to set.

7. *Long-term catheter care*

This subject has been audited by Morris *et al* (1995). Once the wound has healed, there is no need for any dressing. For non-fully implantable devices it is necessary to loop the tails and fix them to the chest. When required, the tails are taken down to avoid twisting at the exit site. The patient should be advised to keep the catheter exit site dry for 10 d and subsequently to use a short-term occlusive dressing while bathing, showering or swimming in order to prevent colonization by Gram-negative organisms, especially *Pseudomonas* spp.

Table II. Catheter flushing protocols.

Catheter	Solutions	Frequency	Cautions
Hickman (Bard) and Hickman-like (e.g. Cook, Vygon)	Heparin 50 u/ml	After access or at least weekly	Maintain positive pressure until catheter clamped
Groshong	Saline	After access or at least weekly	
Apheresis	Heparin 1000 u/ml or 5000 u/ml according to risk of thrombosis	After access or at least twice weekly	Maintain positive pressure Calculate 'dead space' and avoid systemic heparinization
Subcutaneous port	Heparin 100 u/ml If attached to Groshong lines heparin not required	Before and after access or at least monthly	Maintain positive pressure until needle removed
Heparin solutions	50 u/ml, e.g. Heplok 100 u/ml, e.g. Hepflush 1000 u/ml, e.g. Hepsal 5000 u/ml, e.g. unfractionated heparin in saline		

Flushing protocols for the four main types of catheter are shown in Table II. Care must always be taken to maintain positive pressure while clamping the line at the end of flushing in order to avoid reflux of blood.

8. *Patient information*
A patient's guide should include the following sections: (a) What is a central venous (e.g. Hickman) line? (b) Uses of the line. (c) Caring for the line. (d) Keeping the line clean: (i) before exit site healed; (ii) after site healed. (e) Flushing the line. (f) Changing the bung.

A suitable leaflet may be generated locally or may be obtained from Bard Ltd (Forest House, Brighton Road, Crawley, West Sussex, RH11 9BP). Examples of guidance are given in Table III.

Table III.

Do contact your nurse or doctor if your central line is red, sore or oozing pus or if you have a temperature >38°C
Do contact your nurse or doctor if your line becomes damaged or leaks – after placing an extra clamp above the damaged area
Do contact your nurse or doctor if your arm becomes swollen or you notice any enlarged veins on your chest or neck
Do not leave the clamp open unless you are using the line
Do not allow anyone to handle the line if they are not sure what to do

9. *Patient care of own catheter, access and training issues*
Prior to discharge, the clinical staff should ensure that the patient or his/her carer is educated in the use of the catheter. It is more desirable that the patient/carer looks after the line rather than a district nurse inexperienced in its usage. After insertion, initial support in catheter care should come from the parent unit in the form of flushing, dressing and clinical review. Access to the line by different personnel should be kept to a minimum, as the more people using the line the greater the risk of infection. This should be undertaken only by trained staff or the patient him/herself, particularly in the domiciliary setting. Careful hand-washing is essential and gloves should be worn when opening or replacing bungs.

A blood sampling protocol should be developed locally, but ideally would require the removal of the heparinized dead space (approximately 5 ml) prior to sampling. The volume to be removed before coagulation studies are performed is uncertain with central venous lines, but for APTT studies from arterial lines it is recommended that 6 times the dead space volume is removed (Laxson & Titler, 1994). This recommendation is not appropriate for the paediatric patient with a Broviac catheter nor in those patients with an apheresis line whose luminal space contains greater than 5000 units of heparin. Coagulation studies in such circumstances produce erroneous results, and the sample should be taken from a peripheral vein. In the bone marrow transplant setting the lumen for cyclosporin A and other drug levels should be identified and the drugs administered through a different lumen.

10. *Management of problem patients*
(a) If the patient is *thrombocytopenic*, the catheter should be inserted by a jugular approach, with care to avoid puncturing the carotid artery. A subclavian approach is associated with tunnelling through muscle and it is also possible inadvertently to breach the subclavian artery. If the platelet count is $< 50 \times 10^9$/l the patient should be transfused with platelet concentrate, ideally to a count $> 100 \times 10^9$/l. If there is evidence of bleeding post catheter insertion then the

patient should receive further platelet transfusion(s) to maintain the count in excess of 50×10^9/l for the next 48 h. Problems may arise in patients refractory to random donor platelets (Pheeko *et al*, 1996).

(b) In those patients with *disseminated intravascular coagulation*, e.g. in association with acute promyelocytic leukaemia, there should be vigorous correction of any abnormality of coagulation. The prothrombin time should be < 1·3 times normal and fibrinogen > 1·0 g/l. If FDPs are very high this will have an additional adverse effect on coagulation.

Patients on oral anticoagulants should stop their tablets to achieve an INR < 1·3 before line insertion. If time is limited, FFP, factor concentrates or vitamin K may be required, but the latter may interfere with subsequent anticoagulation (BCSH, 1990). Intravenous heparin should be stopped 3 h before insertion and restarted when haemostasis is secured.

(c) *Haemophiliac* patients (with haemophilia A, B or C) will require appropriate factor replacement. Correction should be maintained for > 48 h. Clinicians caring for these patients should seek advice from their local haemophilia reference centre.

(d) *Infection* at the time of line insertion represents a relative contra-indication to proceeding, and consideration should be given to temporary line placement. If the patient has a unilateral skin infection on the anterior upper chest wall, the unaffected side should be used.

(e) A patient who has received previous *radiotherapy* to one side of the chest should have the catheter inserted on the opposite side, although patients with breast cancer may prefer a line inserted under their prosthesis.

(f) If there are symptoms and signs of *venous insufficiency*, subclavian venous stenosis may be reliably diagnosed by injecting contrast medium through the ipsilateral anterior cubital fossa, or more rapidly but less reliably, by ultrasound. This represents a further contra-indication to catheter insertion on that side.

11. *Prevention and management of catheter complications*

The main complications are (a) *thrombosis* and (b) *infection*.

(a) *Thrombosis*. Partial and complete catheter blockage is evidenced by difficulty in aspirating blood or infusing fluid. Forcible introduction of fluid down an obstructed lumen may cause catheter rupture. Catheter blockage may be due to kinking of the catheter in the subclavian vein, occlusion of the catheter tip on the vessel wall, or luminal thrombus. Plain X-ray or a catheter contrast study may be helpful in confirming the diagnosis.

Catheter kinking can sometimes be relieved by a change in the position of the patient and is less common with lateral insertion of the catheter under fluoroscopic control. Occlusion of the catheter tip against the vessel wall can be rectified by tilting the patient head down.

Catheter thrombosis may be spontaneous or may result from a prothrombotic state associated either with underlying malignancy or treatment, particularly with L-asparaginase. Thrombosis may be prevented by adhering to appropriate flushing protocols (see Table II). The use of low-dose warfarin may also be effective and may be particularly indicated in patients who have had a previous catheter thrombosis (Bern *et al*, 1990). However, this study excluded patients with platelet counts < 125×10^9/l or any coagulopathy, and the use of low-dose warfarin in patients with abnormal haemostasis should be approached with caution.

In catheter occlusion due to thrombus but without symptomatic thrombosis, instillation of a fibrinolytic solution such as 2 ml urokinase 4000 u/ml should be tried. The solution should be injected gently into the catheter with a push–pull action to maximize mixing within the lumen. The lumen should then be clamped and left for at least 2–3 h. The catheter should then be unclamped and the solution with disaggregated clot aspirated.

If this procedure fails, or there is symptomatic upper limb thrombosis and the catheter needs to be left *in situ* for further use, a prolonged urokinase infusion through the catheter may be employed (Haire *et al*, 1990). Anticoagulation is indicated following urokinase infusion, but if re-thrombosis occurs a further urokinase infusion may clear the catheter. There are no data on the level of anticoagulation required post urokinase infusion to prevent thrombosis. There are similarly no data on ideal levels of anticoagulation in thrombocytopenic patients nor on the duration of anticoagulant therapy in catheter-related thrombosis.

If the catheter is to be removed some authorities advise urokinase infusion prior to catheter removal, either through a peripheral vein or through the catheter itself. After catheter removal the patient should be anticoagulated. In non-thrombocytopenic patients standard heparin and warfarin is reasonable. In thrombocytopenic patients low molecular weight heparin may be used. One published regimen utilizes enoxaparin 40 mg subcutaneously twice daily for 14 d followed by 40 mg daily for at least 8 weeks (Drakos *et al*, 1992).

(b) *Catheter infection*. Recommendations for good practice regarding prevention, diagnosis and treatment of infections (and other aspects of central venous catheterization) have been published by Elliott *et al* (1994).

There are three categories. (a) A *catheter-related bacteraemia* is defined as at least two blood cultures positive with the same organism obtained from at least two separate sites at different times, in association with evidence of colonization of the catheter with the same organism. The latter part of the definition can only be strictly fulfilled by removing the catheter. Attempts to incriminate the catheter as the source of bacteraemia (without removing it) by using quantitative blood cultures such as the Isolator system (Oxoid) have met with mixed success and the method is labour intensive. Simple sensitive diagnostic techniques are still awaited (Reimer, 1994). (b) An *exit site infection* presents with erythema, tenderness and occasionally a discharge at the insertion site. (c) A *tunnel infection* is characterized by pain and induration along the track of the catheter.

The incidence of these infections varies in different centres with different groups of patients and different practices. In a series of 690 Hickman catheter insertions followed up for a mean of 195 d at a single centre between 1978 and 1987 the incidences of catheter related bacteraemias, exit site infections and tunnel infections were 57%, 23% and 7% respectively (Newman *et al*, 1993).

Table IV. Recommendations for the management of catheter-related infections.

Category of infection	Neutropenic patient	Non-neutropenic patient
Presumed catheter-related bacteraemia/fungaemia	Initial empirical antibiotic therapy: modify according to isolates Treat for at least 10–14 d (consider longer if still neutropenic)	Remove catheter if no longer needed Treat with antibiotics targeted against isolates
	Remove catheter if cultures remain positive after 48 h of therapy or if proven catheter-related infection with *Staphylococcus aureus*, *Bacillus* spp., pseudomonads, *Mycobacterium* spp. or fungi	
Exit site infection	Initial empirical therapy including glycopeptide Treat for at least 10–14 d or longer until infection resolved	Remove catheter if no longer needed Treat empirically with flucloxacillin
	Modify according to isolates. Remove catheter if evidence of progression or if blood cultures positive for *Staphylococcus aureus*, *Bacillus* spp., pseudomonads, *Mycobacterium* spp. or fungi	
	Line may be salvaged by surgical incision and drainage	
Tunnel infection	Remove catheter and drain pus	
	Initial empirical therapy including glycopeptide Treat for at least 10–14 d or until resolution of soft tissue infection	Treat empirically with flucloxacillin
	Modify according to isolates	

The management of catheter infections remains controversial. Attempts should be made to make a microbiological diagnosis by culturing blood from all catheter lumina, a peripheral sample of blood and the exit site before commencing antibiotics. Table IV summarizes current recommendations based upon consensus and the literature. Recent evidence suggests that *in situ* use of glycopeptides may be highly effective and infusion is better than bolus injection (McCarthy *et al*, 1995; Ley *et al*, 1996). The 'antibiotic lock' technique may however be less effective with subcutaneous ports (Longuet *et al*, 1995).

12. *Technique of catheter removal*

Indications for catheter removal include (a) sepsis, (b) irremediable blockage, (c) axillary or other venous thrombosis attributable to the line, (d) exteriorization of the cuff, (e) irreparable damage to the catheter including that caused by 'pinch off' syndrome, and (f) the end of treatment.

Patients should be adequately sedated and receive good local anaesthesia although a brief general anaesthetic may be required. (a) Simple traction on the catheter may be effective. (b) It may be necessary to dissect the Dacron cuff. (c) If difficulty is encountered, insertion of a guide wire is recommended followed by dissection of the Dacron cuff. Bard catheters are designed such that the cuff can remain behind. This is not desirable for neutropenic patients, and if the catheter is removed for infection the cuff should always be removed.

It is important to remove the catheter in the direction of the tunnel. The line should be inspected carefully after removal to ensure that it is complete and the tip sent to the microbiology department for culture. After removal, the patient should be sat up and pressure applied to the exit point, tunnel and venotomy site.

13. *Repair of damaged catheters and tip retrieval*

Only trained personnel should be allowed to undertake these tasks. If the catheter tip is sheared off during removal, it is likely to travel into the pulmonary artery. Either a 'basket' or a 'lassoo' technique is used to retrieve the tip under fluoroscopic guidance. Repair kits should be available to rectify catheter damage and a variety must be stocked if different lines are in use. Further details are beyond the scope of these guidelines.

14. *Recommendations for audit*

A locally based audit should include patient identification data, diagnosis, date of line insertion, number of previous lines, operator and department where line inserted, complications associated with the line, date of and reason for removal.

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