Abstract

Oncology patients are frequently faced with difficult venous access requirements. Access is required for chemotherapy and frequent blood testing, which rapidly consumes peripheral access, often on and off for prolonged periods. Long-term venous access devices have the potential of minimising the quality of life implications for such patients whilst preserving peripheral veins.

Venous access devices, including implantable catheters (ports), tunnelled catheters and peripherally inserted central catheter (PICC) lines, all have relative advantages and disadvantages. Choice of device will often revolve around both patient factors and local preference. Image guided placement is the preferred method of insertion in most institutions due to its higher success rates and lower morbidity and mortality. Secondly, such physicians are usually well suited to address many of the catheter complications and place alternate access catheters in the compromised venous patient.

Vascular access is a common problem facing oncology patients. Access is required not only for dose intensive chemotherapy, but also for frequent blood sampling and intravenous supportive measures. Vascular access devices provide reliable venous access and may protect peripheral access and increase patient comfort through reducing repeated and difficult venipuncture.

The perfect catheter should be placed in a large vein allowing rapid dilution of infused products, free aspiration of blood and reduced pain on injection. This catheter should also be biocompatible, whilst minimising catheter related infection, thrombosis, stenosis or occlusion of access site. There are numerous types of catheters available for this purpose and selection is dependent upon type and duration of access, patient factors, physician and local factors.

Venous access, however, is not without complication. Although insertion and placement problems are rare with modern access and imaging techniques, catheter related infection, thrombosis and loss of function continue to be major problems. The oncology patient is also often immunosuppressed, prone to febrile periods and is often thrombogenic from the underlying disease.

Venous access devices

Venous access devices can be divided into implantable devices, tunnelled catheters and peripherally inserted central catheter (PICC) lines.

Placement is similar for all devices; the chosen vein is entered either percutaneously using the Seldinger technique or surgically cut down. The catheter tip is ideally placed either into the right atrium or the cavo-atrial junction. Catheter tips that end in the SVC or brachiocephalic vein have a higher incidence of catheter failure due to fibrin sheaths, venous stenosis and thrombosis. PICC lines are fastened to the skin at their exit site. Tunnelled catheters are passed subcutaneously for a variable distance before exiting the skin. Ports are buried subcutaneously (not exiting the skin) after being tunnelled for a short distance.

Favoured access sites for tunnelled catheters and ports include jugular and subclavian veins. A low right internal jugular access has the least likelihood to develop catheter dysfunction, venous stenosis or occlusion. PICC lines and arm ports may be placed in basilic, brachial, cephalic or axillary veins.

The majority of procedures in adults are done percutaneously utilising the Seldinger technique. Percutaneous procedures have been shown to be superior to surgical cut-downs in terms of theatre time, cosmetic result, local infective complications and placement complications. A study comparing surgical cut-downs with percutaneous techniques found a failure rate of 4.5% and multiple attempts in 13% in the surgical group, compared with none in the percutaneous group. Furthermore, 3.7% of surgically placed catheters were misplaced compared with none in the percutaneous group. There were subsequently 4.0 infections per 1000 catheter days in the surgical group compared with 1.9 in the percutaneous group. Some authors also believe that surgical access will compromise the vein for future use in a way that percutaneous puncture does not. The only disadvantage of the percutaneous technique can be the rate of pneumothorax, which in this study was 3.3% (compared with 0.8% for the surgical group). However, it is my belief when ultrasound and micropuncture access is used (figure 1), pneumothorax is a very rare occurrence. Secondly, image guided placement allows for accurate catheter tip placement increasing the rate of technical success and reducing the rate of catheter dysfunction. Image guided placement has become the insertion method of choice in many institutions, as it has reduced morbidity and mortality, as well as reducing costs and length of hospital stay.

Long-term venous access patients may well be challenging because of venous pathology due to previous procedures and underlying medical problems. When the classical access sites are no longer patent, ongoing access may require recannalisation of
Translumbar placed portacath in man with bilaterally occluded brachiocephalic veins.

the central veins or alternate catheter placement sites. Alternate access sites include external jugular, brachiocephalic, femoral, transhepatic, collateral and translumbar access. Such access can usually be provided safely and relatively easily through specialised interventional radiology services (figure 2).

Implantable venous access

Ports are totally implanted devices comprised of metallic or plastic casing with a thick injection membrane on the superficial aspect. The ports may be single or double housing and are placed subcutaneously on the anterior chest wall, lower lateral costal margin or upper arm. A Silastic catheter is tunnelled from the housing to the access vein and the tip is sited as per other forms of long-term venous access. Percutaneous access is gained by placing a non coring Huber type needle through this membrane. The site of needle placement is determined by palpation of the port. The advantages of ports are greater cosmetic acceptance, less maintenance and allow the patient greater freedom to bathe and swim. Ports are particularly useful when shorter periods of intermittent use are required. Disadvantages are that they are more time consuming to place and more expensive than tunnelled catheters. Patients with generous subcutaneous tissues are often not suited to this form of access due to difficulty to palpate the entry to the housing for each access. Conversely, very emaciated patients may suffer from port erosion. Arm ports compare favourably with chest ports and would seem to have similar thrombotic and infective rates.\(^\text{4}\)

Tunneled access\(^\text{5}\)

Originally described by Hickman and colleagues in 1979, these catheters are the two or three-fold increase in price and no evidence of any long-term effects. The disadvantages of these catheters were in place for longer than 14 days and there is no evidence of any long-term effects. The disadvantages of these catheters are the two or three-fold increase in price and the potential risk of increased antibiotic resistance.

Complications

Procedural complications are rare with meticulous technique, image guided insertion and image guided punctures. They include pneumothorax, haemothorax, arterial puncture, catheter malposition, haematoma and air embolism. The Society of Interventional Radiology’s published guidelines on image guided central venous access recommend a threshold of 3% for major complications (rates exceeding a threshold should prompt a review of that service).\(^\text{1}\)

Indwelling complications include infection, thrombosis, catheter malfunction and catheter fracture. Catheter fracture is rare (< 1%), while the other three are problems integral to all long-term catheters. Catheter malfunction has an incidence of 10-20%, this is often related to fibrin sheath formation or catheter associated thrombosis. The incidence may be minimised with meticulous access and tip placement.\(^\text{5}\)

Infection

Infection is an important cause of morbidity, mortality, and increased health costs with long-term vascular catheters. Infection includes exit site infection, tunnel or port infection and catheter related blood stream infections; it does not
necessarily include colonization of the catheter.

Biofilm formation on catheter surfaces is an important part of the pathogenesis of catheter infection. Use of electron microscopy determined that central venous catheters removed from patients had universal colonization in the form of biofilms. Biofilms are created by irreversible attachment of micro-organisms to the surface of the catheter, producing a matrix of extracellular polymeric substances. Biofilms also provide protection for micro-organisms by inhibiting the diffusion of antimicrobials. Short-term catheters are usually nontunnelled catheters that become infected by microbial colonisation along the external surface of the catheter caused by migration of skin flora along the catheter within 10 days of insertion. In contrast, infections of nontunnelled catheters that have been present for longer than 10 days are usually caused by intraluminal colonisation.

PICCs are believed to be associated with lower rates of infection than other nontunnelled catheters. While the use of tunnelling and implantable ports reduces the risk of external colonisation and catheter infection. Tunnelled catheters have a dacron cuff that is located a few centimeters proximal to their exit site in the subcutaneous tissue that anchors the catheter in place and is thought to create a barrier against migration of skin flora along the external surface of the catheter. Ports are fully implanted subcutaneously and therefore should have no contact with external skin flora. However, Infections of long-term catheters are frequently associated with intraluminal infection.

Traditionally, catheter removal has been considered the standard of care for catheter related blood stream infections (CRBSI). However, the advent of tunnelled catheters and implantable ports has prompted many to consider treating CRBSIs with systemic antibiotics without catheter removal because of the invasiveness associated with removal and reininsertion of long-term catheters. As this approach has become more popular, substantial data has emerged suggesting that the success of catheter salvage often depends on the location of infection, the infecting pathogen, and the host's immune status. For exit-site infections, antimicrobial therapy alone may be adequate because the mechanism of infection involves a localised soft-tissue infection. However, a tunnel or port infection mandates catheter removal because these infections generally involve biofilm formation along the external surface of the catheter, which cannot be adequately treated with systemic antimicrobial therapy. There have been many open trials of standard intravenous therapy for CRBSIs with attempted salvage of tunnelled catheters that found success rates ranging from 18% to 100%. If catheter salvage is attempted, systemic antimicrobial therapy should be used in addition to antibiotic lock therapy. There is no standard on the timing of catheter replacements for catheter related infections, we replace our catheters at 5-7 days post catheter removal if there are no further febrile episodes or positive blood cultures. A new tunnel is created and the right side is favoured, even if the previous catheter was sited there.

Thrombosis

Despite routine flushing with heparin or saline, 41% of central venous catheters (CVC) result in thrombosis of the blood vessel, markedly increasing the risk of infection. Efforts to reduce CVC thrombosis with systemic prophylactic anticoagulation with low-molecular-weight heparin have failed and low-dose warfarin prophylaxis remains controversial. In an autopsy study of patients with CVCs, all 55 patients examined developed a sleeve and, in phlebographic studies, 45 of 57 (78%) patients had a fibrin sheath. A venographic study by De Cicco et al, showed that 83 of 95 (87%) patients had these sheaths. These fibrin sheaths over time are always colonised by cocci. However, fibrin sheaths do not equal or predict subsequent deep vein thrombosis of the vessel in which the catheter is placed.

A very common and usually under-reported event is the development of thrombus within the lumen of the catheter. This usually is uncovered when the catheter fails to allow blood to be withdrawn or fails to allow infusion through a port. Treatment is by locking the catheter with fibrinolytic agents such as urokinase, streptokinase and tissue plasminogen activator (TPA) and is successful in some 80%–95%.

The major thrombotic complication of CVCs is deep venous thrombosis. These mural thrombi may partially or completely block the blood vessel and involve 12%–74% of all CVCs. Most (~71%) are asymptomatic. Venographic studies have shown that approximately 41% (range 12%–74%) of all patients with CVCs developed thrombi. The pathologic effects of CVCs on blood vessels were studied in 74 consecutive autopsies of cancer patients with CVCs in which the cannulated vessel was compared with the contralateral vessel that was not cannulated. Venous pathology (hemorrhage, thrombosis, calcification, ulceration and inflammation) was found in 49% of the cannulated blood vessels but in only 9% of those that were not cannulated. Furthermore, mural thrombosis was seen in 30% of the cannulated vessels and in only 1% of those not cannulated. Nonetheless, symptomatic pulmonary embolus (PE) is relatively rare having been reported in approximately 6% of all patients with upper extremity DVT. However, we have placed three
superior vena cava filters in patients with pulmonary emboli for catheter related venous thrombosis in the last 12 months. (figure 4)

Although, malignancy is a risk factor for catheter related thrombosis, catheter tip position is the major determinant of central vein thrombosis. Placement of the catheter tip high in the superior vena cava (SVC) results in a higher incidence of thrombosis than when the catheter tip is placed low in the SVC. 11 In addition, CVCs inserted from the left subclavian vein clotted more commonly than did CVCs inserted from the right subclavian vein. 12 In a recent study, 14 of 16 (87%) left side CVCs versus 49 of 79 (62%) right side CVCs were reported to leaving a normally functioning central access. (figure 5)

The benefit of systemic prophylaxis with LMWH or warfarin is not been well established. Venous thrombosis causing central catheter malfunction is treated by infusing a thrombolytic through the catheter overnight and this usually resolves the thrombus (figure 4)

**Conclusion**

Tunneled catheters, ports and PICC lines are important means of providing intermediate to long-term central access in oncology patients. Image guided placement has been shown to have the greatest success and lowest complication profile and now represents the standard in most institutions for insertion of these devices.

**References**