38 Central Venous Access

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Introduction

Approximately 200,000 central venous lines (CVLs) are inserted in the UK annually and a significant proportion are indwelling lines inserted for the administration of chemotherapy or to serve the other needs of patients with oncological problems.

The advances in cancer care have been paralleled by similar advances in central line design and construction. The history of central access and treatment through indwelling catheters is relatively short: in 1968 Dudrick et al. [1] inserted a catheter in the superior vena cava of beagle puppies that was maintained in situ for a long period. Broviac et al. introduced a catheter suitable for long-term use in 1973 [2], and Hickman modified this in 1975 [3] by increasing catheter wall thickness and lumen diameter. The evolution of materials used to construct these catheters has also been revolutionized by the replacement of thrombogenic, relatively noncompliant, and variably antigenic rubber, nylon, polyvinyl, or polyurethane catheters with those made of silicone, associated with a concomitant decrease in the complication rate and duration of indwelling catheter time.

Multiple lumen catheters have been designed for use in patients requiring long-term simultaneous administration of two or more parenteral solutions, e.g., chemotherapy, antibiotics, antifungal agents, and parenteral nutrition. Since the introduction of intravenous therapy teams, there have been dramatic improvements in catheter and catheter site care, bringing about a reduction in complications [4]. Furthermore, the introduction of fully implantable central access systems (Figs. 38.1 and 38.2) has afforded further benefits, especially freedom of lifestyle, to these patients [5, 6].

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Indications for the Insertion of Central Lines

Patients with oncological problems will almost always require treatment with chemotherapy. Administration of chemotherapy is the most important specific indication for the insertion of a central venous line. However, the needs of cancer patients are oft en quite complex; therefore, a CVL may be required for other uses besides chemotherapy.

Administration of Chemotherapeutic Agents

The use of multiple lumen catheters has been of particular value in patients requiring multimodal treatments. Patients undergoing bone marrow transplantation require vascular access during preparation for transplant, high-dose chemotherapy, and total body irradiation.

Supportive therapy is also required during preparation for engraftment and following transplantation.

Administration of Intravenous Alimentation

Intestinal complications of chemotherapy requiring bowel rest (e.g., typhlitis) or effectively leading to a malabsorption type syndrome occur relatively frequently in neutropenic patients with leukemia during aggressive treatment with chemotherapy [7]. Many children with cancer are malnourished during their induction of chemotherapy, manifesting in weight loss. Their nutritional requirements can be met by parental feeding despite inadequate absorption from the gastrointestinal tract. Nutritional support can also be maintained without the need for long hospital stays through home parenteral nutrition programs.

R. Carachi, J.L. Grosfeld (eds.), *The Surgery of Childhood Tumors*, DOI 10.1007/978-3-662-48590-3_38

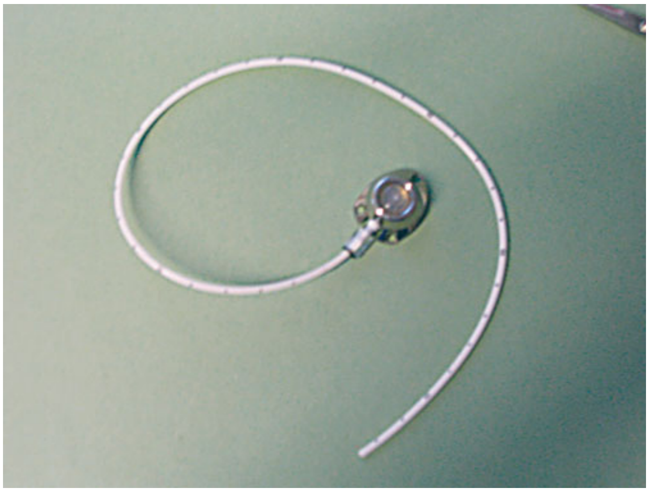

Fig. 38.1 Fully implantable device (port-a-cath) allowing patients a much less restricted lifestyle

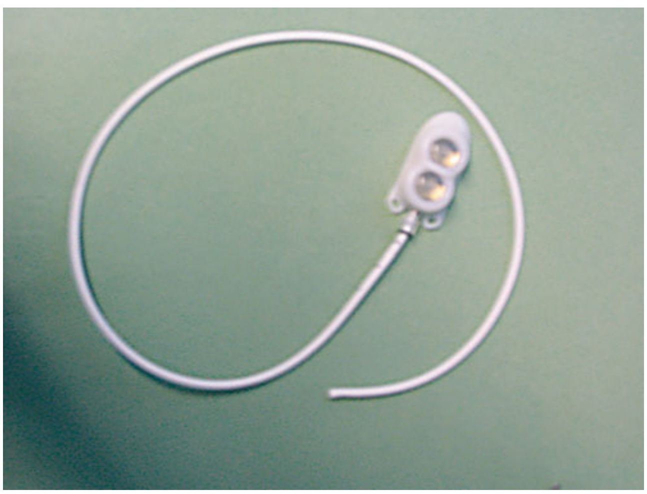

Fig. 38.2 Dual lumen port affording the advantages of double lumen lines in a totally implantable device

Resuscitation

Central access is also invaluable in the intensive care unit and monitoring of these patients, pre- and posttransplantation, during and after major oncological surgery, and in the management of complications such as tumor lysis syndrome.

Monitoring and Repeat Blood Sampling

Monitoring central venous pressure is important in monitoring patients in the intensive care facility or during major surgical procedures. Frequent blood sampling, from the catheter during courses of chemotherapy, avoids the need for frequent venepuncture in the pediatric patient.

Administration of Antibiotics

As many of these patients are immunocompromised, they may require frequent courses of intravenous antibiotics for prolonged periods to manage episodes of systemic sepsis.

Repeated Transfusion of Blood and Blood Products

CVLs are used for the administration of whole blood, packed cells, white cells, platelets, and plasma factors, and plasma may be required in patients with granulocytopenia, immune suppression, and patients with recurrent or chronic blood loss. Central lines are also useful for patients requiring exchange blood transfusions and apheresis.

Hemodialysis

This may be necessary for various reasons [8] and a specially modified large caliber line (semi-rigid dual lumen catheter) can be inserted to allow hemodialysis to be performed. It is possible to use the same tract of an existing central line and sequentially dilate it with special venous dilators to permit insertion of the hemodialysis catheter. This preserves a valuable entry point to the central circulation as oncology patients are likely to require multiple line insertions.

Methods of Venous Access

General Principles Applying to Gaining Intravenous Access: "The 5A's"

- Asepsis
- Antisepsis
- Adequate access
- Anatomical placement
- Avoidance of complications

All the above are self explanatory: aseptic technique should be employed with appropriate antisepsis of the surrounding skin/tissues. Chlorhexidine is superior to betadine as it is associated with a lower incidence of line infection [9]. The line inserted should be adequate for the purpose intended (single/multiple lumen, appropriate diameter, etc.) and should be inserted in the appropriate central location. The operator's experience and appropriate choice of the technique for insertion are also important factors in avoidance of complications.

Peripheral Venous Access

Peripheral venous access is indicated for short-term administration of fluids and drugs. There are a number of advantages over central venous access. There is evidence that drugs administered peripherally reach effective levels as quickly as those given centrally as long as they are flushed with a bolus of saline [10].

The basilic and cephalic veins in the antecubital fossa and the dorsal veins of the hands and feet are usually easily accessible in most patients. The origin of the cephalic vein in the "anatomical snuff box" is a site favored by medical staff, earning it a reputation as the "house-man's vein." Occasionally cannulae may need to be inserted blindly, where no vein is visible or palpable. In this situation veins which are relatively fixed in their position such as the medial cubital vein or the long saphenous vein at the ankle are useful. Different peripheral cannulation sites are more appropriate in different age groups. In neonate and infants, the scalp is a useful alternative site for peripheral access, although it is necessary to shave the hair around the site of insertion.

Some agents when given peripherally can contribute to the development of vasculitis (e.g., calcium, dopamine, chemotherapy agents); however, parenteral nutrition can be successfully administered into peripheral veins. Patients who require only short-term nutritional support are ideal candidates for this peripheral parenteral nutrition. Advantages of using peripheral access include the avoidance of the complications associated with the insertion and the care of central venous cannulae. However, administration of chemotherapy commonly leads to complications if given in the periphery. Other means to reduce the incidence of thrombophlebitis and prolong the life-span of peripheral lines include the simultaneous administration of fat emulsion (intralipid) and the use of a topical vasodilator such as transdermal glycerin trinitrate [11].

Peripheral lines are available in a variety of diameters, each color-coded in a universal manner, regardless of manufacturer. The smallest cannulae have the highest gauge.

Peripherally Sited Central Venous Access

The risks involved in central line insertion can be avoided by using specifically designed silicone catheters that can be placed in a peripheral vein and advanced into a more central position (PIC-line). This allows the administration of solutions that may be venotoxic when given peripherally, but avoids some of the complications associated with central line insertion [12].

Most commercially available long-lines come with an introducing kit. Ideal sites for insertion include the antecubital fossa veins, the femoral vein, or in small children the long saphenous vein at the ankle. To reduce the incidence of complications, if an upper limb vein is used the catheter should be advanced into the superior vena cava, and if a lower limb vein is used it should lie in the external/common iliac vein [13]. There have been recent reports of this type of cannula being associated with cardiac tamponade, after the tip of the line migrated through the wall of the right atrium [14, 15] leading to the recommendation that the tip of the line should rest in the central veins rather than the right atrium. The less compliant polyurethane lines of extremely fi ne caliber (e.g., <2 FG) are most likely to cause this problem, partially due to the high pressure "jetting" effect at the tip of the line [16].

Central Venous Access

Central venous access is indicated if venous access is required for a prolonged period of time, if peripheral access is unsuccessful, or when hypertonic or venotoxic solutions are to be used. Central lines are available in two major forms – polyethylene catheters that are more rigid and suitable for short-term access/monitoring, and silicone catheters that are more suited for long-term use. The complications of central line insertion are listed in Table. 38.1. The site chosen, underlying condition of the patient, and the experience of the clinician determine the incidence of these complications [22]. Junior trainees should be supervised until they feel comfortable and demonstrate competency in carrying out this procedure.

As the list of complications is long, the clinician may be tempted to advise repeated peripheral cannulae. In a large review of 585 children who required venous access, Ziegler et al. found that in 385 with peripheral lines there was a complication rate of 9 %, and in 200 children with central access, the rate was 20 % [23]. However, as the central lines were in place for a longer period than the peripheral lines, the complication rate per patient per day was actually lower in the central line group.

The reported risk of developing a catheter-related infection ranges between 1 and 20 % [17], but this should also be expressed as "per 100 intravascular device days." Infection can be reduced by meticulous aseptic technique at the time of insertion and each time the line is accessed or the dressing damaged at the exit site. A 2 % chlorhexidine solution is an

Table 38.1 Commonest complications of Central Line Insertion

Complication	Incidence [reference]
Infection	1–20 % [17]
Hemorrhage	1–3 % [18]
Dislodgement	7 % [19]
Phlebitis	4 % [18]
Thrombosis	1.5–3 % [18, 19]
Thromboembolism	1 % [18]
Air embolism	Rare (<0.1 %) [20]
Pneumothorax	2 % [21]
Hemothorax	0.2 % [21]

appropriate choice of agent and appears to be superior to betadine [9]. A collagen subcutaneous cuff as found on some central lines can reduce the risk of infection if the patient is nonseptic at the time of insertion [24]. The cuff can also add to the security of the line if inserted to a distance of greater than 2 cm from the exit site [25].

Manufacturers of commercially available central lines are listed in Table. 38.2. A recent modification popularized in the USA is the Groshong valve [26]. This patented system allows the tip of the catheter to be rounded and closed. The valve opens inwards when blood is aspirated and outwards during infusions. It remains closed when the line is not in use so clamping of the line is not necessary. Lines only require flushing once weekly.

There are three main sites commonly used for central lines – the subclavian vein, the femoral vein, and the neck veins (internal and external jugular veins). Each of these sites will be discussed.

Catheterization of the Subclavian Vein

The subclavian vein may be percutaneously catheterized using the Seldinger technique [27]. The apex of the lung lies higher on the left so pneumothorax is a more common complication using this side (Fig. 38.3). Unless there is a suspected cervical spine injury, this technique is facilitated by placing a roll under the thoracic spine, thereby extending it, a head down position to engorge the great veins, and the patient facing towards the contralateral side.

Technique

1. Scrub hands and observe strict aseptic technique.
2. Cleanse the patient's skin with an antiseptic solution and drape appropriately. The wider the sterile field, the better.
3. Infiltrate local anesthetic (e.g., 0.5 % bupivacaine) to an area 0.5 cm below the clavicle just lateral to the mid-clavicular line.
4. Attach a 2.5-ml syringe onto the needle and flush with heparinized saline.
5. Puncture the skin just below the clavicle lateral to the mid-clavicular line and advance the needle superiorly until the clavicle is met. Manipulate the needle to pass under the clavicle and point the tip medially.
6. At this point flush a very small amount of saline through the needle to evacuate any plugs of skin or tissue in the needle.
7. Place a finger of the other hand in the sternal notch, and direct the needle towards this target, gently aspirating the syringe as the needle is advanced.
8. Visualize the needle passing under the clavicle towards the tip of the finger in the sternal notch.
9. Free aspiration of blood indicates the correct position. If this is not achieved, withdraw slowly, while aspirating. Flashback of blood almost invariably occurs as the needle is withdrawn.
10. Once the vein has been accessed, firmly secure the end of the needle with one hand, and with the other remove the syringe. There should be free flow of blood from the end of the needle at this time.

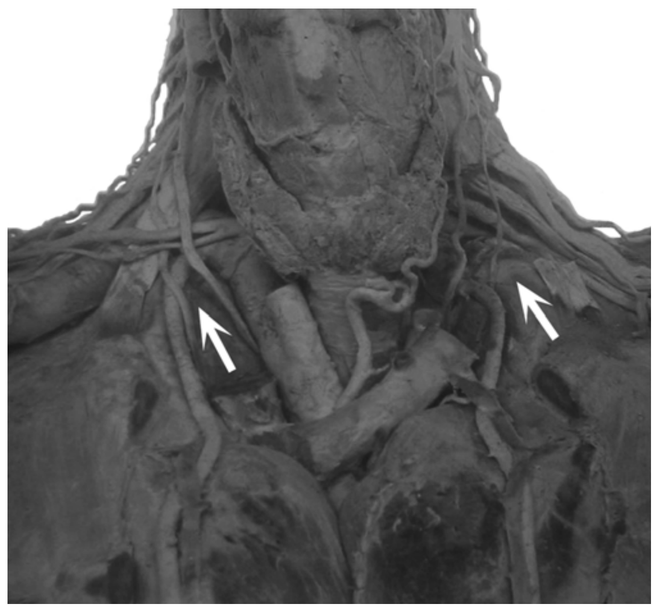

Fig. 38.3 Anatomical specimen of the neck and thoracic inlet showing the protrusion of the apex of the lung/pleura (*arrows*) in close proximity to the sites of percutaneous puncture for accessing the subclavian veins

Table 38.2 A selection of central line Manufacturers

Name	Address	Device
Vygon Corporation	East Rutherford, NJ	Various
Gesco International	San Antonio, TX	Per-Q-Catheter, various
Dow Corning	Ithaca, NY	Various
Pharmacia Inc.	St. Paul, MN	Port-a-cath, various
Bard Corp	Murray Hill, NJ	Various
Cook Inc.	Bloomington, IN	Broviac, various

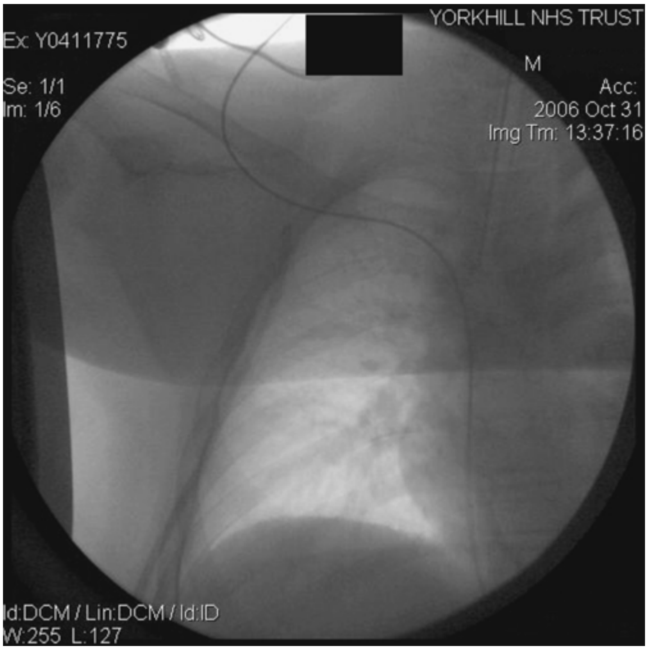

Fig. 38.4 Guidewire passed through needle into the heart. On this occasion it traversed the right atrium and terminated into the IVC and was withdrawn prior to the procedure continuing

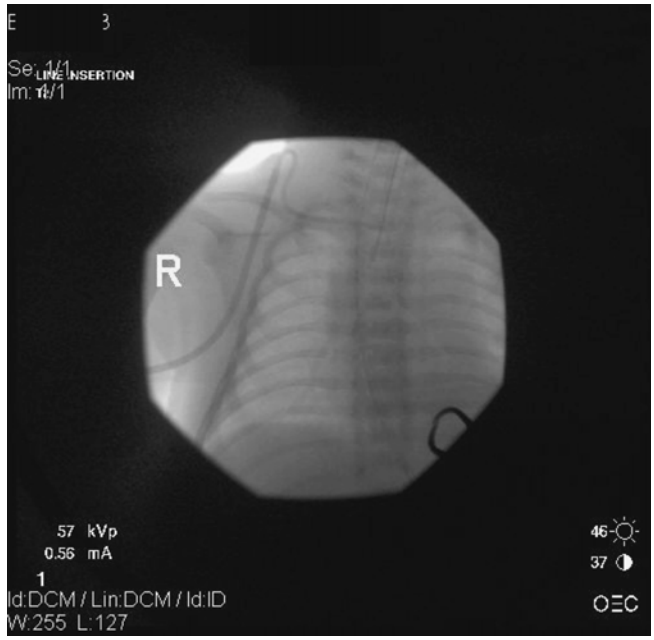

Fig. 38.5 Inappropriate position of CVL tip into the innominate Vein

11. Pass the guidewire through the needle until the tip is in the vena cava (Fig. 38.4). This should pass easily; if this is not the case, this indicates incorrect placement. This part of the procedure should be done with image intensifier help.
12. Remove the needle over the guidewire and make a small skin incision to allow the exit of the tunneling device and catheter and also subsequently the passage of the tissue/venous dilator and split sheath introducer.
13. Tunnel the line from a position lateral to the areola of the breast to the guidewire entry point and cut to size (ideally with the help of the image intensifier).
14. Pass the dilator over the guidewire and with a gentle but fi rm advancing and rotating force, advance the venous dilator/split sheath introducer into the SVC/RA.
15. When the correct position is radiographically confirmed, the guidewire and venous dilator are removed leaving the outside thin split sheath introducer in situ. This allows the tip of the previously tunneled catheter to be advanced to the correct position (SVC/RA junction) and the sheath split and removed while holding the catheter in place.
16. Advance the catheter over the guidewire until it reaches the desired position, then remove the guidewire.
17. Flush all lumina of the line and secure it in place using one of several methods to reduce the chance of displacement and migration [28–30].
18. Confirm that bilateral breath sounds are present.
19. Proper catheter position should be documented in all cases with a chest radiograph as inappropriately positioned lines should be remanipulated (Fig. 38.5).

Catheterization of the Femoral Vein

Percutaneous femoral vein catheterization has been used for long-term venous access (it is also the site of access for many invasive vascular techniques, e.g., cardiac catheterization, embolization, etc.). In the absence of significant abdominal distension the central venous pressure recorded through a femoral line is also an accurate reflection of supradiaphragmatic venous pressure [31]. Although it would seem that femoral lines are more likely to be complicated by infection there is no evidence of this [32]; indeed there is a lower rate of insertion-related complications compared to other sites [21]. Thrombotic complications, however, are more common.

For long-term access, the femoral vein is cannulated by a long saphenous vein cut down at the groin. A subcutaneous tunnel is fashioned to the anterior abdominal wall after the vein is exposed. A cuffed catheter can then be inserted through the tunnel and into the vein and can be advanced to the desired level up to the right atrium (Fig. 38.6).

Catheterization of the Jugular Veins

The external and internal jugular veins can be used for central access. Both can be accessed percutaneously or by an open technique. The external jugular vein is an appropriate site for venous cut down in children under general anesthetic and the number of complications related to insertion is low. Indeed, it is the site of choice for the insertion of the first central line in this institution.

Fig. 38.6 A femoral line placed into the IVC

Percutaneous access of the internal jugular vein is preferably performed on the right. The pathway to the right atrium is straight, and there is virtually no chance of thoracic duct injury. Again, it is best if the patient is placed head down with a roll under the shoulders to extend the neck, with the patient facing the contralateral side. If there is suspected cervical spine trauma this position will not be possible. Recently published guidelines (2002) from the National Institute for Clinical Excellence have recommended the use of 2-dimensional ultrasound to locate the vein prior to percutaneous insertion. This policy increases the success rate of internal jugular venous access in children although the avoidance of arterial injury is not as marked as in adult practice [33]. This technique has also been described with subclavian access [34].

Totally Implantable Devices

These consist of central venous lines that are inserted as documented above but instead of being tunneled to an exit site, a port is buried in a subcutaneous pocket, usually on the lateral chest wall, and secured through small fixing holes in its periphery. The port is a chamber with a self-sealing injection port (Figs. 38.1 and 38.2). A recent addition to the choice of ports is a dual lumen device, with the obvious advantages it affords (Fig. 38.2). The ports are made of stainless steel, titanium alloy or synthetic plastic materials and have a silicone dome on the anterior surface to allow access. The silicone compound has "bleeding" properties such that after the needle is withdrawn, the access hole seals spontaneously. Access to the port is achieved via a specially designed "non-coring" Huber needle through the skin (Fig. 38.7).

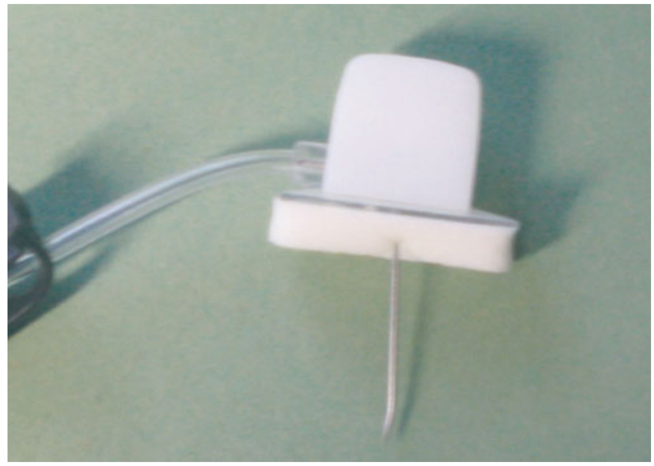

Fig. 38.7 Close up view of the Huber needle, which is constructed in such a way to penetrate the silicone dome of the port reservoir by pushing away the layer of silicone instead of "coring" through its thickness

Advantages of implantable devices include decreased infection rate with appropriate care [35], decreased dislodgement rate [25], minimal maintenance [36], and freedom of activities [37]. The most pleasing aspect of these devices to our patients is the ability to continue with normal activities such as swimming and other sports. Although access to the port involves puncturing the overlying skin, this is initially sensitized by using local anesthetic cream (EMLA, Ametop) until the area eventually becomes insensitive as time progresses. The skin, however, may break down over the patch and lead to complications, e.g., infection.

Complications of CVLS and Their Treatment

A central line, however carefully and expertly inserted, is still a foreign body in direct contact with the circulation. Most of the potential complications have already been reported and studied (Table. 38.1), but the clinician should remain vigilant to identify and treat any potential permutation or new complication that may arise. Infection is a serious complication, especially in immunocompromised patients and can be treated aggressively with antibiotics with reasonable success [38], although in the setting of sepsis, 20–60 % of catheters will be removed [35]. Some organisms (e.g., staphylococcus epidermidis [39], pseudomonas species, and candida albicans [40], etc.) are virtually impossible to eradicate and will require line removal and a new line to be inserted. Although some success is reported by replacing the line through the same tract [41], in severely immunocompromised patients the commonest protocol involves removal of the line, antibiotic administration, and line replacement several days later once the infection is controlled. There is a paucity of published evidence regarding an optimal delay before line reinsertion. Published articles pertain predominantly to the use of short-term central venous lines in the intensive care setting and extrapolation of this evidence to cuffed tunneled lines is tenuous. One controversy with short-term central lines is the practice of routine replacement to prevent catheter-related sepsis. In a telephone survey in 1997, 52 % of intensive care units in the UK had a policy of replacing lines before 7 days [42]. Recommendations from the USA do not support a practice of routine replacement [43].

Another relatively recent advance is the introduction of antibiotic-impregnated lines [44], which are reportedly associated with lower rates of bacterial colonization [45]. Techniques used include bonding minocycline and rifampicin to both internal and external surfaces or chlorhexidine and silver sulfadiazine to the external surface [46]. This technology is widely available with percutaneously inserted central lines rather than tunneled long-term central lines. However, these lines are less compliant as a result of the manufacturing process of impregnation and careful consideration should be made prior to their use.

Hemorrhage can be caused by damage to the vein, inadvertent puncture of an artery or the heart [47], and exacerbated by thrombocytopenia/impaired clotting in pancytopenic patients. While in most cases general measures (mainly local pressure application) suffice, in some, vascular reconstruction/emergency cardiac surgery may be necessary to correct the problem. Mortality is indeed associated with this thankfully rare complication. Phlebitis is rarely observed with correctly positioned central lines and is more commonly the result of peripheral administration (mainly through necessity) of venotoxic solutions or due to displacement of the tip of the central line from the correct position. Thrombosis is also a sequel of the presence of the line in the circulation as such and this may lead to vein stricture and/or thrombosis. Pulmonary embolus is a rare complication usually resulting from the dislodgement of a thrombus from the right atrium (RA). Keeping the catheter tip proximal to the RA avoids this complication.

Prior to each use, the line should be checked for free flow of blood both ways. If in doubt, a chest radiograph and possibly an echocardiogram should be performed to assess the position and presence of thrombus around the line. Early detection and treatment will reduce the chances of thromboembolic complications. Air embolism can occur during insertion of the line or through a breach of the integrity of the line. The former can be avoided if the patient remains in head down position until the line is inserted, flushed, and sealed and the latter by regular careful inspection of the integrity of the line and all obturator parts.

Pneumothorax is a well-recognized, although rare, complication of percutaneous subclavian vein access and all patients/families should be warned about this possibility. If recognized early, it is successfully treated by the insertion of a chest drain. Chylothorax is a very rare complication of central venous access, almost exclusively after left -sided approach due to the proximity of the thoracic duct to the confluence of the internal jugular vein with the left subclavian. It can be avoided by ensuring open approaches remain above the confluence of the two great veins.

If the line is advanced too far (i.e., into the RA), it can cause atrial arrhythmias by interfering with the SA or AV node or ventricular arrhythmias by interfering directly with the ventricular myocardial wall. In such cases, the line should be remanipulated in the correct position as soon as possible. Fracture of the catheter, if complete, can result in the distal segment embolizing into the pulmonary vasculature. This can be successfully retrieved through a transfemoral minimally invasive technique best done in the cardiac catheter suite.

Many unfortunate patients require repeated insertions of central lines over long periods of time and this eventually results in obliteration/thrombosis of the available veins. In order to avoid fruitless invasive explorations, an angiogram would be indicated if a new attempt at central access is required in such a patient. Until recently, the investigation of choice was a formal angiogram, which is associated with a high level of radiation and the possibility of allergic reaction to intravenous contrast, or B-mode ultrasound, but these investigations have now been virtually superseded by detailed MR angiography which can effectively guide the surgeon to the appropriate vessel while at the same time being safer and much less invasive for the patient (Fig. 38.8).

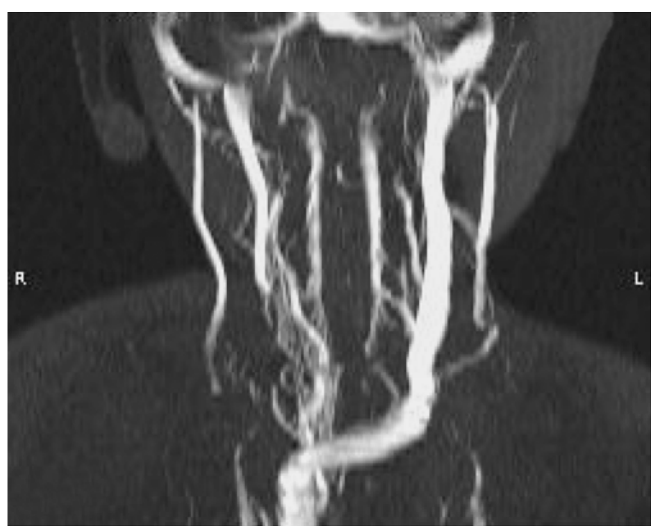

Fig. 38.8 MR venogram showing complete occlusion of the right internal jugular and subclavian veins with the development of tortuous collateral circulation. CVL cannulation was achieved by percutaneous subclavian access of the innominate vein

Summary

Technological advances in material manufacture and design have revolutionized the safety of implantable central lines, by reducing their antigenicity and thrombogenic potential, while at the same time augmenting their longevity in the circulation. Surgical technique has evolved in parallel to allow for safe and minimally invasive placement of these lines that afford a more successful and comfortable method of administering the necessary chemotherapeutic and supportive agents to oncology patients.

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