VASCULAR ACCESS... BEYOND THE PERIPHERAL CATHETER

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Vascular access is extremely important in medicine. Peripheral intravenous catheters are placed percutaneously numerous times each day in patients that are being placed under anesthesia/sedation or those being admitted to the hospital for treatment. Unfortunately, peripheral venous access is not always possible in patients who are very small, morbidly obese, hemodynamically unstable or critically ill. Below we are going to discuss alternatives to traditional peripheral intravenous catheters when they cannot be placed.

Venous cutdown

Venous cutdowns are indicated when veins are small, such as in very small patients or those that are severely hypovolemic, or when the vein is obstructed (subcutaneous edema, morbidly obese patients). A venous cutdown involves making an incision through the skin with a blade next to the vein to allow for better visualization. To perform a venous cutdown the skin should be shaved and asymptotically prepared. In awake patients, sedation or local anesthesia to the region will be required. Sterile gloves and a drape should be used. A 1 – 2 cm incision is made through the skin parallel to the vessel. The incision should not be made directly over the vessel and care should be made not to incise the vessel. The subcutaneous tissue is then bluntly dissected free. An encircling suture is placed proximally and distally around the vessel to help exteriorize and immobilize the vein. The catheter is then inserted into the vessel. The proximal suture is then tied around the catheter to secure the catheter in place. The skin is then closed with skin sutures and a bandage is placed.

Intraosseous catheterization (IO)

Intravenous catheterization can be very difficult in patients with small or collapsed veins. When intravenous catheterization cannot be performed, intraosseous catheterization should be considered. The bone marrow is a semifluid blood-forming tissue that is encapsulated by non-expanding bone and therefore does not collapse during circulatory failure. Fluids and medications injected into the medullary canal quickly enter the venous circulation through the medullary capillaries. Several studies have shown that fluids and medications injected intraosseously enter circulation at similar rates when compared to central or peripheral intravenous injection.
Intraosseous catheter placement is contraindicated if there is known fracture of the bone, local skin/tissue infection, known osteomyelitis or recent intraosseous catheterization of the same insertion point.

Placement

Intraosseous catheterization can be performed using a variety of materials including hypodermic needles, spinal needles, intraosseous infusion needles, bone marrow needles and commercially available intraosseous catheters. Hypodermic needles (18g – 25g) can be used in neonates and exotics as their bone cortices are very soft. In cat, small dogs and birds, spinal needles (18 – 22g) can be used and in adult dogs bone marrow needles and/or commercially available intraosseous catheters should be used. Commercially available bone injections guns exist as well to help with IO catheterization.

Site choice is made based on the experience and preference of the clinician. The most commonly used sites for IO placement are the flat medial surface of the proximal tibia, the tibial tuberosity and the trochanteric fossa of the femur. Other possible sites include the wing of the ilium, the ischium and the greater tubercle of the humerus.

The site should be shaved and asymptomatically prepared. Local anesthetic will likely be necessary in alert patients as the periosteum is highly innervated. A small skin stab incision can be made to help with ease of needle placement. The needle is then positioned perpendicular to the surface of the bone. The needle is then rotated clockwise and counterclockwise with constant pressure to penetrate the bone cortex. Once you have entered the medullary canal there will be a loss of resistance.

Confirmation of proper placement should be performed prior to medication administration. A correctly positioned catheter should be firmly seated in the bone and should move with the limb. Gentle aspiration of the needle should also result in bone marrow aspiration. Heparinized saline should also flush easily through the catheter and no subcutaneous fluid accumulation should be noted.

The needle should then be secured to the patient. A tape butterfly can be placed around the hub of the needle and the tape can be sutured to the skin. The area should then be covered with antiseptic or antibiotic ointment and bandaged. The catheter can then be maintained similarly to an intravenous catheter.

Placement into the trochanteric fossa of the femur starts with the region being shaved and aseptically prepared. A local anesthetic block can be used in conscious patients. The femur is then gripped with the non-dominant hand and is rotated internally while holding the limb perpendicular to the spine. This is performed to prevent sciatic nerve injury. The thumb of your non-dominant hand should be placed parallel to the femur to help determine the orientation of the needle. The needle is then introduced through the skin with your dominant hand and walked off the medial aspect of the greater trochanter into the trochanteric fossa. The needle should then be rotated in a clockwise and counterclockwise fashion with constant pressure until the cortex is breached. Proper placement should then be confirmed as directed above prior to administration
of fluids or medications. For placement into the medial tibia the needle must be directed slightly distal to the proximal growth plate using the technique discussed above.

Complications

The rate of complications with intraosseous catheters is relatively low. The most common reported complication is osteomyelitis. Other possible complications include catheter site infection, nerve damage, extravasation of fluids, fat emboli, compartment syndrome and bone fractures.

Central Venous Catheterization

Central venous catheterization is the placement of a catheter that terminates in the cranial or caudal vena cava. These catheters can be introduced directly through the jugular vein or through a peripheral vein (peripherally inserted central catheter - PICC lines). Indications for central venous catheterization include the administration of long term fluid therapy/medications, hemodynamic monitoring and blood sampling. These catheters have a number of benefits over peripheral catheters in that they can be left in place for prolonged periods of time in critically ill patients. Multiple lumen catheters also allow the administration of numerous fluid types and medications that are not compatible with each other. Hyperosmolar solutions, parenteral nutrition and medications known to cause phlebitis can also be administered through these catheters with less risk of phlebitis. Hemodynamic monitoring, including central venous pressures and central venous blood sampling can also be obtained with these catheters. These catheters can also improve patient comfort while in the hospital as blood sampling can be performed via central venous catheters. Although central venous catheterization can be very helpful in critically ill patients, it should not be performed in those with active seizures, intracranial disease, immune-mediated hemolytic anemia, head trauma or other untreated coagulopathies.

Catheter type:

There are a number of different catheters that can be used for central venous catheterization including through-the-needle catheters, long over-the-needle-catheters, single and multilumen central venous catheters and catheters placed through a central venous catheter sheath.

Long single and multilumen catheters are placed using the modified Seldinger guidewire technique or peel-off sheath. There are a number of commercially available kits that can be purchased with different gauge and length catheters. Single lumen catheters are typically used for blood sampling purposes or central venous pressure monitoring. Multilumen catheters can be purchased as double, triple or quadruple lumen catheters. These catheters are extremely helpful in critically ill patients. Medications that are not typically compatible can be given concurrently through different lumens and they mix immediately in the circulating blood.

Central venous jugular catheters are inserted directly into the jugular vein in the cervical region of dogs and cats. These catheters are placed antegrade towards the heart and terminate in the cranial vena cava. Long line central venous catheters can also be placed in the saphenous veins. The lateral or medial saphenous vein can be used in dogs while the medial saphenous vein is typically used in cats.
Strict aseptic technique should be performed when placing central venous catheters. Sterile gloves should always be worn during placement and a drape should be used to maintain sterility. Below we will discuss the most common central venous catheter placement techniques via the Seldinger technique and the through-the-needle technique.

**Seldinger technique**

The Seldinger technique uses a smaller introducing catheter and/or trochar and a guidewire to obtain vessel access. Prior to placement the distance for catheter insertion should be determined. Jugular central venous catheters should terminate just cranial to the right atrium in the distal cranial vena cava. This distance can be determined by measuring the distance from the insertion site to the caudal edge of the triceps muscle or first rib with a seamstress tape measure. This measurement can then be used to aid in catheter selection. For jugular vein placement the patient is placed in lateral recumbency and a gauze roll or towel can be placed under the patient’s neck to help expose the vessel.

The insertion site is then generously clipped and aseptically prepared. Sedation may be required based on the patient’s level of consciousness. Local anesthetic can also be used but care should be made to ensure intravenous injection does not occur. All materials should be opened in a sterile manner. All lumen ports should be flushed with heparinized sterile saline and then capped with the exception of the distal port, which is where the guidewire will be passed. The insertion site should then draped to help decrease the risk of contamination. After identifying the vein a small relief skin incision is made with an 11 or 15 blade over the insertion site. Care should be made to ensure the underlying structures are not traumatized. The introducing needle or short over the needle catheter is then placed through the relief skin incision and into the vessel. The stylet is then removed and the guidewire can be threaded through the needle or catheter. Many guidewires have a flexible J-tip to prevent puncture of the vessel. If you are unable to pass the J-tip you can utilize the straight end of the guidewire but this can be more traumatic to the vessel. The guidewire should be held by the operator at all times to prevent embolism. Approximately, two thirds of the guidewire should be introduced into the vessel. While keeping hold of the guidewire the introducing needle or catheter is removed and the vessel dilator is then feed over the guidewire. The dilator is then fed down the guidewire and inserted into the vessel with a twisting motion. Once the vessel is dilated the dilator is removed with the guidewire being left in place. Direct pressure with sterile gauze sponges should be placed over the insertion site to minimize blood loss as the dilator is removed. The selected catheter is then fed over the guidewire until the proximal end (end closest to the operator) of the guidewire protrudes through the distal port. The proximal end of the guidewire is then held as the catheter is inserted into the vessel to the desired distance. The guidewire is removed and the port is occluded to prevent air embolism. All ports are then aspirated to remove any air and to ensure patency. Blood should be obtained from all ports. If blood is not obtained the catheter should be repositioned to allow for blood aspiration. The catheter ports are then flushed with heparinized saline to prevent clotting and the catheter is sutured in place. The insertion site should be covered with sterile gauze and bandaged. Radiographs are then taken to ensure proper positioning. If the catheter is
placed too far in (in the right atrium) the catheter should be backed out and resecured to the patient as this may increase the risk of thrombus formation.

**Through-the-needle technique**

Through-the-needle catheters can be placed through commercially available catheters. The entire needle tip is inserted into the lumen of the vessel. The needle is then stabilized and the catheter is threaded through the needle into the vein. Once the catheter is fully advanced into the vessel, pressure is placed over the insertion site and the needle is backed out. Once bleeding has stopped the needle guard is placed and the catheter is aspirated to confirm patency and remove any residual air. It should then be flushed with heparinized saline and capped. The catheter is then sutured in place. Sterile gauze should be placed over the insertion site and the limb bandaged.

Alternatively these catheters can be placed through a peripheral intravenous catheter by removing the long single lumen catheter from the insertion needle. The single lumen is then inserted through a short peripheral intravenous catheter. The two catheter hubs are then attached and the catheters are secured to the patient with butterfly tape and sutures. Sterile gauze should still be placed over the insertion site and the limb bandaged. This method is helpful is smaller patients where the insertion needle is too large or those patients that already have peripherally placed intravenous catheters.

**Catheter maintenance**

All unused ports of the central venous catheter should be flushed with heparinized saline every 4 hours. The bandage over the catheter should be changed daily and the catheter insertion site visually inspected daily. The insertion site should then be gently cleaned with dilute chlorhexidine and the sterile gauze and bandage should then be replaced. Sterile gloves should be worn cleaning the insertion site.

**Complications of catheter placement**

Complications of catheter placement can occur regardless of the type of catheter placed.

Phlebitis is inflammation of the vessel wall secondary to endothelial damage. Clinically, phlebitis can be seen as swelling or redness of the skin over the vessel and pain when flushing or handling the catheter. Phlebitis can occur as a result of certain medications (especially those that are hyperosmolar), secondary to catheter displacement or infection. Thrombosis occurs when a blood clot is formed at the tip of the catheter or vessel wall. Thrombotic vessels can “stand up” without being held off and can feel thick and cordlike. These changes are commonly seen in tandem with phlebitis. If phlebitis or thrombosis is suspected the catheter should be removed and replaced into a different vessel if continued IV access is needed.

Catheter embolism occurs when any portion of the catheter breaks off and enters circulation. This can occur when stylets are removed or when catheters are accidentally cut during bandage removal. If a catheter embolisation is suspected the vessel should be immediately occluded and a cut down should be performed to remove the embolized fragment. If the vessel is not
immediately occluded the catheter fragment may not be able to be removed or could travel to distant sites (such as the lungs) leading to significant morbidity.

Extravasation of fluids is another common complication of catheter placement that occurs secondary to displacement of the catheter out of the vessel or upstream thrombosis. This can be seen as swelling proximal to the catheter site. If noted the catheter should be removed and replaced into another vessel.