The occasional intraosseous infusion

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Introduction

Long bones in infants are filled with marrow that contains vascularized sinusoids. These sinusoids eventually drain into the systemic venous circulation. The marrow cavity acts as a rigid vein and so will not collapse, even in the face of severe volume loss. No matter how dehydrated or volume-depleted the child is, there is always a rigid tube that can be punctured to replace the required fluids.

The marrow is very vascular in infants. At about age 5, this marrow is replaced by less vascular marrow, and, although the intraosseous (IO) route is still available in older children and adults, it is a more difficult route for rapid volume replacement, compared with venous access. It is, however, still a good route for giving medications if peripheral access is not possible, and advanced cardiac life support protocols now prefer IO access over the endotracheal route for drug administration.[1,2]

Although bolus medications are rapidly effective, it is necessary to do a saline flush after each drug, and to administer volume under pressure using syringe and stopcock, infusion pump or pressure bag. Maximum rate of administration is equivalent to a # 21 peripheral cannula.[3]

Indications

1. Vascular access is difficult or unsuccessful. Peripheral vein access tends to be difficult in small children, for whom this procedure is used most. Older children and adults have a denser bony cortex, making IO procedures more difficult, while peripheral venous access is simpler.
2. The first vascular access in children in full cardiac arrest or severe shock should be IO infusion unless intravenous access is already in place. Establishment of airway and ventilation is always the first priority in these patients.[2]
3. Some sources suggest that failure to establish intravenous (IV) access within 90 seconds or 3 attempts mandates a switch to IO access.[2]

Contraindications

1. Compromise of the insertion site by trauma, burn or infection
2. Ipsilateral laceration or fracture, which would divert the volume being given
3. Pelvic fracture
4. Abnormality of bone, such as osteogenesis imperfecta or severe osteoporosis
5. Previous failure to establish IO cannulation in the same extremity, which would increase the risk of compartment syndrome

Complications

1. Local cellulitis or subcutaneous abscess occurs in 1% of cases.
2. Hypertonic or irritating solutions can cause muscle necrosis if leakage occurs.
3. There is a risk of hematoma.
4. Osteomyelitis is rare.
5. There is a risk of growth plate or joint injury if the site of penetration is badly chosen. The risk is minimized by directing the needle away from the growth plate.
6. Compartment syndrome is reported. The risk rises with the length of time the infusion is employed.

7. Sepsis is rarely reported.
8. Fat embolism is rarely reported.
9. The risk of all complications increases with the length of time the infusion is employed, and is minimized by removal within 3–4 hours. The same site of penetration may be used for 72–96 hours if there is no alternative.[4]

Equipment

The following equipment is required (Fig. 1):

1. Sterile bone marrow Sur-Fast (Cook Medical Inc., Bloomington, Indiana; Fig. 2) or Jamshidi (Baxter Corp., Mississauga, Ontario; Fig. 3) needle, 15–18 gauge, 2.5–5.0 cm length
2. Povidone–iodine and alcohol prep solutions
3. Lidocaine 2% (preservative-free if given by IO route)
4. One 10-mL syringe containing saline and 1 empty 5-mL syringe
5. One 60-mL syringe
6. IV fluid bag and primed administration set ready for immediate use
7. Appropriate needles for local anesthetic administration and drawing up bolus fluids
8. 3-way stopcock
9. Saline solution for flushing lines
10. Tape and 4 × 4 gauze to secure IO needle

Fig. 1. Equipment includes a bone marrow needle, a 3-way stopcock, povidone–iodine prep swabs, lidocaine (preservative-free if used for an intraosseous route), needles for aspiration and anesthesia, 10-mL normal saline flush, 5-mL and 60-mL syringes, and saline with primed intravenous tubing set for immediate fluid administration.

Procedure

1. Identify the insertion site.
   - For children, on the proximal tibia anteromedial flat surface 1–3 cm (width of 1–2 fingers) below and medial to the tibial tuberosity. Can be directed caudad 10–15 degrees to avoid the growth plate.
   - Alternate site for children — distal femur 2–3 cm above the epicondyles in the midline, directed cephalad at an angle of 10–15 degrees from the vertical.
   - For adults, an additional site is the distal tibia 1 cm above the superior margin of the medial malleolus or the sternum.
2. Position the patient and immobilize the limb. It may be helpful to place a small rolled-up towel under the knee.

Fig. 2. Sur-Fast intraosseous needle.

Fig. 3. Jamshidi intraosseous needle.

3. Prep using sterile technique with povidone–iodine. In a nonurgent situation, wait 2 minutes and remove with alcohol.
4. Infiltrate locally with lidocaine 2% to the periosteum.
5. Recheck landmarks.
6. Hold the limb firmly at the level of the knee. Do not put your hand behind the knee in the path of the needle at any time.
7. With the obturator in the bone marrow needle, puncture skin at the chosen site. Once the periosteum has been reached, direct the needle at a 10–15 degree angle away from the adjacent joint. Advance the needle by gently rotating it as you push it ahead. When the needle pops into the marrow space, a lack of resistance is detected (Fig. 4). To allow more stability in the procedure, hold the needle between the index finger and thumb, about 1 cm from the tip, with the cap of the obturator against the palm of your hand.
8. Remove the cap and obturator and see if marrow appears. If it does not, attach an empty syringe, and try to aspirate back marrow or blood (most physicians now omit this step because it may draw the bone plug back into the syringe).[5] This action can cause some visceral pain. A lack of marrow on aspiration does not necessarily mean poor placement. If you are in the right place, the needle should stand securely on its own. Any aspirated blood can be sent for chemistry or culture, type and screen, drug levels and hematology.[5]
9. Because marrow clots very quickly, immediately take a second syringe filled with 5–10 mL of sterile saline and flush the needle while checking the back of the limb for swelling, which would indicate leakage into the soft tissue or under the periosteum. There should be no resistance with proper placement. If fluid does not flow easily, try advancing the needle further.
   - If these measures fail, or if swelling becomes apparent, try reinsertion in the other limb with less angulation. If reinsertion is done in the same limb because of suspected blockage, it must be at the same site, as the original site can leak and cause compartment syndrome.
10. If good flow is confirmed, attach a 3-way stopcock and the IV tubing. For conscious patients, 2 mL lidocaine 2% (preservative-free) will eliminate visceral pain during volume infusion.
    - For volume resuscitation, 30–60 mL aliquots of fluid can be administered rapidly by syringe. Alternatively, a pressure bag or IV infusion pump can be used.
    - After any drug administration, always do a 2–10 mL saline flush to avoid a depot effect.
11. The inserted needle will protrude at the penetration site. Secure it with sterile gauze and strapping. Do not tape circumferentially or obscure the site with dressings. Continue to check for extravasation or calf swelling.
12. As soon as volume replacement improves perfusion, obtain 1 or 2 reliable peripheral sites and consider removal of the IO access site.

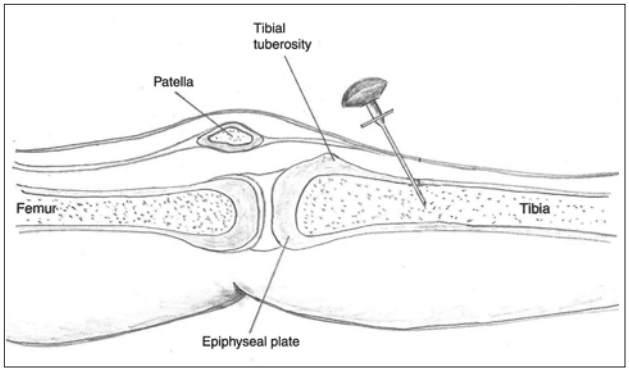

Fig. 4. The intraosseous needle is directed 10–15 degrees away from the growth plate with a gently twisting motion. Loss of resistance indicates entry into the marrow cavity.

Adult intraosseous access

Because the success rate is high with occasional use, and the IO route is always available in circulatory collapse, this technique is being used more frequently in adults, particularly in prehospital, trauma or military settings. Higher bone density makes for more difficult access, therefore alternative techniques for bone penetration have been devised.

1. Standard IO needle use has had a 50% success rate by paramedics in the field with patients over age 10.[6]
2. The FAST-1 (Pyng Medical Corp., Richmond, British Columbia) device provides fast and accurate sternal placement. Emergency department trials have shown success rates of 74% for first-time users and 95% for experienced users. This may be particularly useful for patients with lower extremity or pelvic trauma.[7]
3. The Bone Injection Gun (WaisMed Ltd., Houston, Texas) is a compact spring-loaded device that places a pencil point needle at a preset depth into bone. It has been extensively used by the Israeli military.[3,8]
4. The EZ-IO (Vidacare Corp., San Antonio, Texas) device uses a battery-powered drill to place the IO needle at a specific depth. Prehospital

trials show an 87% success rate. The FAST-1 device used in the same trial showed a success rate of 72%.[9]

Important points to remember

1. This is the most rapid method of intravascular access in young children.
2. A vast variety of fluids can be administered by this route.
3. The technique can probably be done proficiently despite infrequent use.[10]
4. This is a temporary measure for fluid replacement until vascular access is possible by another route. Alternate access should be planned after a few hours.
5. Calf circumference should be followed carefully to detect fluid entering soft tissue compartments.

Competing interests: None declared.

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