HOW I USE THE INTRA-OSSEOUS SPACE FOR IV ACCESS AND SAMPLING

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Introduction
The intraosseous (IO) space is a non-collapsible entry point into the systemic circulation that can essentially be thought of as the continuous and equivalent to the intravascular space. The IO route is often used when an intravenous route cannot be obtained. This is often the case in very small or young patients whose veins are too small to easily catheterize or in any age patient in a state of hemorrhage or dehydration when the peripheral veins are collapsed. The big advantage with the IO space is it does not collapse and is always accessible regardless of the state of the vascular system.

Manual vs. automated IO devices
The choice of manual IO devices varies with the age of the patient and ease of placement. In young animals with a soft bone cortex regular 18-25g hypodermic needles may be used. An 18-22 g spinal needles may be preferred as they have a stylet to keep the needle lumen patent from blocking with cortical/medullary bone. In older patients, or patients in which it is difficult to traverse the cortex of the bone, Jamshedi bone marrow needles or commercial manual intra-osseous needles may also be tried (i.e.: Cook intra-osseous infusion needle).

As a result of the difficulty in placing hand held devices in older patients, automated devices have been developed and are now available to veterinarians. The EZIO is probably the more commonly used automated device in veterinary medicine and is available as 15 g needle in lengths of 15, 25 and 45 mm.

What are the indications for IO catheter placement?
Any emergency situation where venous access cannot be rapidly obtained (i.e. trauma, cardiac arrest, status epilepticus, burn and shock patients) and young patients where vessels are too small to easily catheterize (IO devices often placed manually in these patients).

It should be noted that there is evidence to suggest the initial aspirate obtained from the IO catheter prior to flushing can be used for diagnostic studies including: Hemoglobin, hematocrit, glucose, BUN, creatinine, type and cross, blood gas and blood cultures.

What are the absolute contraindications with IO devices?
- Fracture or compromise (risk of pathologic fracture) in the target bone
- Compartment syndrome in the target extremity
- Vascular injury in the target extremity (i.e. tibia is intact but there is a femoral fracture with significant soft tissue and vascular related injury in the proximal target limb)
- Acute infection at the insertion site
- Previous orthopedic surgery with hardware at the insertion site
- Recent failed IO attempt in same extremity (within 24-48 hours) – this leads to extravasation from the previous IO catheter insertion site

What are the relative contraindications with IO devices?
- Cellulitis or burns to the target extremity
• Sepsis or bacteremia (note this is systemic illness, not local infection of the target site which is an absolute contraindication)
• Unable to palpate landmarks

What are the reported possible complications of automated IO use?
≤ 1% in human studies
• Minor bleeding
• Fracture of the bone (rare)
• Osteomyelitis (rare with appropriate sterile technique and removal of catheter within 24 hours) - human recommendations are to remove the device within 24 hours.
• Pain (treated with lidocaine infusion – see below)
• Extravasation of fluid (can be up to 20% of cases) Risk factors include: incorrect needle placement, incorrect needle length and multiple punctures in the same bone. Osseous punctures can take 12-48 hours to clot; therefore, subsequent IO placement in the same bone should be avoided during that period
• Compartment syndrome – a serious result of extravasation when fluid leaks out of the bone into the surrounding tissues (may increase with high pressure rates and prolonged infusion times) – can be a very serious complication
• Catheter dislodgement (i.e.. as patient starts moving)
• Fat embolism (demonstrated in dogs after 4h of IO infusion although there was no clinical correlation (no change in PaO2 or shunt fraction))

Note that obtaining gravity drip rates with a pressure bag does not mean malposition of the catheter, although the site should be verified for extravasation/compartment syndrome.

What drugs can be delivered via the IO route?
Most drugs given IV can be given IO including but not limited to blood products, synthetic colloids, hypotonic crystalloids, isotonic crystalloids, parenteral nutrition, opioids, antibiotics and most other IV medications (not all drugs have been evaluated by the IO route so it is impossible to say all drugs given IV can be given IO, but many have been investigated and found to be safe to administer IO). There are reports of tissue necrosis with extravasation of some drugs including hypertonic solutions (hypertonic saline, 10-50% dextrose), epinephrine, norepinephrine and sodium bicarbonate.

It should be noted that although hypertonic solutions (hypertonic saline and 10-50% dextrose) can cause histologic evidence of bone marrow necrosis following their administration, the clinical significance of the necrosis has not established and most patients seem to do well following hypertonic IO fluid administration.

How quickly can an automated IO device be placed and with what success rate?
In pre-hospital ambulatory settings the success rate of IO devices in humans is 84.8% in less than a minute. In states of pre-hospital cardiac arrest, successful vascular access was achieved 91% of the time with IO devices compared to 43% via a peripheral vein. With BIG devices cadaver studies show a success rate of 94%. A recent veterinary study demonstrated automated IO catheter placement is much faster than performing an IV cut down.

What is the risk of infection with automated IO devices?
Risk of osteomyelitis in people is 0.6%. Most of these infections occurred during prolonged infusions or in situations of concurrent bacteremia at the time of IO catheter placement.

What flow rates are expected with IO devices?
IO flow rates tend to vary with the size of the IO catheter used, the application of pressure bags/infusion devices, and the location the IO catheter is placed. The humerus tends to achieve the fastest flow rates in most studies when compared to the tibia. There is also evidence that humoral IO injections reach the heart more quickly during CPR than injections administered into the tibia.

Is it painful to place an automated IO device?
Human studies report a score of 1-3 for pain on a visual analog scale of 1-10 (similar to insertion of an 18 g catheter into the vein) when the IO catheter is inserted/traverses the cortex. The discomfort reported with IO devices is likely less painful with automated devices. However, as the IO space contains nerve fibers that are sensitive to pressure, patients report a pain rating of 5 out of 10 during infusion of fluid. That said, several studies have shown the administration of preservative free 2% lidocaine into the IO space via the IO catheter can adequately manage the discomfort associated with infusions. It is recommended to wait 60 seconds to achieve affect and then follow the lidocaine bolus with a 3-10 ml bolus (pending patient size) of normal saline. It is reported that IO lidocaine may lose effectiveness after roughly 45 minutes and a repeated injection (not to exceed 3mg/kg total) of lidocaine be administered. Can IO samples be used to assess blood chemistry values?
Preliminary evidence suggests that Intraosseous aspirates can be used as a surrogate to venous blood for assessment for glucose, lactate, bicarbonate, pH, PCO2, total solids, sodium, chloride, blood urea nitrogen and anion gap in dogs. Although there was a statistically significant difference. However, for potassium and packed cell volume, and hematocrit the difference between IO and IV samples could impact clinical case management, and therefore should not be used interchangeably.

How to place an IO catheter

**Manual IO placement:**

1. Make a stab incision through the skin
2. Seat the needle into the cortex by pushing the needle lightly into the bone while rotating it about the long axis (about 30 degrees in either direction).
3. When the needle is seated in the cortex, the pressure applied to it is increased while it is rotated and forced through the cortex. A sudden loss of resistance is often felt as the cortex is breached.
4. A properly placed needle should move with the bone when the leg is manipulated and will not move when flicked.
5. A 12 ml syringe is used to apply negative suction to check for the presence of marrow cells. After confirming the position of the needle, it is flushed with lidocaine 0.5 mg/kg over 30 seconds (IO fluid is painful to administer) then flushed with heparinized saline (5-10 ml/kg bolus). Administered fluids should flow freely via gravity if the needle is in the marrow cavity – once free gravity flow of fluids is confirmed, fluids may be administered via pressure.
6. After placement, the needle is fixed in position by passing suture through the periosteum and then to the hub of the needle or to butterfly tape attached to the hub. Cover site with an antiseptic and apply a doughnut bandage that is thick enough to cover the entire hub of the needle. Bandage material is applied to help hold the doughnut bandage in place.

**Needle types:**
- 16-20 g bone marrow needle (dogs and cats)
- 18-22 g spinal needle (cats and young dogs)
- 18-25 g hypodermic needle (neonates of any species)
- Commercial Intra-osseous needles (i.e.: Cook intra-osseous infusion needle)
Figures 1A-E - Common sites for manual and automated IO catheter placement: 2A,B) The medial tibia is a commonly used automated site in adult animals given its ease of location and high success rate for first time attempts to place an IO catheter. 2C,D) The femur is commonly used in younger animals with a soft cortex, but not commonly used in the emergency setting in older animals. 2E) The lateral humerus can also be used and has the advantage of being located in closer proximity to the heart (better for CPR), has faster flow rates and equivalent placement success rates to the medial tibia in humans.

How to place EZIO automated IO catheter

- Landmarks are palpated to confirm the site of placement (common sites used include the medial tibia (see figure 2A,B) and lateral humerus (see figure 2C)
- Clip and aseptically prepare a 2x2” area of skin centered on the site of placement.
- A small (3mm) skin incision is made at the intended site of placement. This is done to prevent the skin from twisting around the catheter during placement
- The catheter with stylet is attached to the drill and seated against the bone, perpendicular to the surface of the bone. With the catheter seated against the bone, there must be at least 3-5mm of clearance between the skin surface and the hub of the catheter. This is to allow room for the catheter to advance into the medullary cavity without compressing the overlying soft tissues.
- While maintaining gentle downward pressure, the drill is activated and the catheter advanced until a decrease in resistance is appreciated.
- Detach the drill and remove the stylet.
- Marrow can potentially be aspirated at this time, though inability to aspirate marrow does not equate to failed placement. Marrow can potentially be used for blood-gas analysis.
- Lidocaine (0.5 mg/kg) is administered IO over 30 seconds
Flush with saline. During the flush, the limb adjacent the IO catheter site and along the opposite side of the bone (in case the opposite cortex was penetrated) is palpated to determine if any extravasation of fluid is appreciated. You'll find that there is more resistance to administering fluids IO compared to IV and this is normal.

If no extravasation is appreciated, a T-port can be connected, fluid therapy is initiated and catheter is bandaged in place.

Removal of the EZIO catheter
- The T-port is removed
- A clean EZIO stylet of the appropriate size is placed inside the lumen of the catheter and locked in place
- While twisting clockwise, the catheter is retracted
- After removal, inspect the catheter and stylet for bending or breakage
- Although intended for single use only, the catheter and stylet can be re-sterilized for future use

References