EMSWORLD

Intraosseous Infusion: Not Just for Kids Anymore

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CREATED: MARCH 1, 2005

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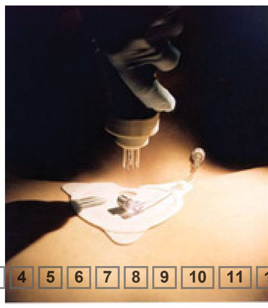
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The potential use of intraosseous (IO) infusions for adults was first examined 80 years ago. Until very recently, this procedure was most commonly considered a rescue technique for pediatric patients, and then only after all else had failed. However, the use of IO access is making a comeback! Once again, it is being recognized as a valuable adjunct to adult, as well as pediatric, fluid and medication administration. This change has taken place primarily as a result of increasing recommendations to more rapidly consider the IO route, extend usage beyond our youngest patients and evaluate the potential of new and improved devices.

This article reviews the indications for pediatric and adult IO placement, addresses many of the concerns associated with the procedure and introduces several new devices available for this potentially lifesaving technique.

Intraosseous infusion is "an effective, reliable and relatively simple technique, both for obtaining rapid vascular access and for the administration of fluids and medications in the emergency setting."[1]

It is well known that establishing intravenous access in an infant or young child is challenging even under normal circumstances.[2] In the prehospital and emergency department settings, few things provoke generalized apprehension like the need to place an intravenous line in a critically ill child. Experienced nurses and paramedics know that it is hard enough to start an IV on a healthy child, not to mention one who is sick or injured. To make matters worse, add the effects of vasoconstriction to naturally small veins, and the result is a situation that most providers would simply describe as a nightmare.

Although a potential solution for this problem was first suggested over 80 years ago, it was generally restricted to resuscitating critically ill children. Since the 1920s, it has been recognized that the bone marrow functions as a "non-collapsible" vein and is able to provide a route for rapid vascular access.[3,4] This medical breakthrough had important applications, especially for pediatric resuscitation, because children may not seem to have veins, but they always have tibias. Recent developments have made IO access an even more important tool in our arsenal of available options that can be used for the sickest kids and adults as well.

Despite widespread use of venous catheters, it is recognized that potential major limitations of prehospital resuscitation relate to time delays and failure rates associated with obtaining vascular access.[4]

IV access provides a "lifeline" for critically ill or injured patients. In both the EMS and ED arenas, the time needed to obtain that lifeline is the key. Placing an IV in an adult in a moving ambulance can take 10--12 minutes, with a 10%--40% failure rate.[5] Studies of pediatric IV attempts by EMS providers have shown that as many as one-third of IV attempts took longer than five minutes to complete and one-fourth took longer than 10 minutes. In 6% of the attempts, there was complete inability to obtain IV access.[6--8] With time being such an important consideration, we can compare these results with studies showing a 70%--100% success rate for pediatric and adult intraosseous placement, often within one minute.[9--11]

Shock, Blood Flow and Bones

A brief review of shock and blood flow may be helpful in understanding the potential of intraosseous infusion. In shock, blood is shunted to the "core" organs, namely the heart, lungs and brain, and away from the periphery (including our favorite IV sites). The body is saying, "What do I really need to stay alive right now? Heart, lungs and brain. What do I not need? Everything else." This self-protective mechanism makes peripheral intravenous access, even in the most skilled hands, difficult, if not downright impossible. In contrast with the peripheral vasculature, the intraosseous space--a rich network of blood vessels within the bone--remains unchanged by the effects of shock. Though the peripheral veins are "clamped down," access to blood flow through the "non-collapsible veins" remains an option in infants, children and adults.[9,12]

IO Indications

Indications for IO access focus on the need for immediate vascular access in situations where peripheral IV attempts appear to be difficult or have been unsuccessful. These are situations where delays in providing necessary treatments can endanger the patient.[14] Pediatric resuscitation guidelines often use the phrase "90 seconds, three attempts or whichever comes first" in describing the limitations that should be followed when attempting to obtain peripheral IV access in children in cardiac arrest.15,16 A practical approach is to pursue IO and peripheral or central venous access simultaneously.17

Historically, IO infusions have been limited to use in pediatric patients; however, recent technological advances have made IO devices a viable and reliable alternative to traditional adult IV access. Adults who are in a state of shock or cardiac compromise present with many of the same challenges to obtaining IV access as our pediatric patients. Recently, the potential for using intraosseous infusions in adult resuscitation has been presented with some interesting results.18 Whether it's for septic shock in infants, dehydration in children or adult cardiac arrest, burns, seizures or traumatic injury, intraosseous infusion is a viable option across the lifespan.4,10,18--22

IO Contraindications

Contraindications to initiating an intraosseous infusion are few. The only universally accepted contraindication for IO access is a fracture of the bone to be used as an access site. Relative contraindications to IO access include diseases such as osteogenesis imperfecta, severe osteoporosis and cellulitis over the insertion site.10,12 In addition, once an IO has been attempted in a bone, further attempts at IO access in that bone are not to be done due to potential leakage from the previous attempt site.17

Access Sites

Where should an IO device be placed? Traditionally, the suggested sites for an IO infusion in children have been the proximal or distal tibia or distal femur.23 In adults, the most commonly recommended sites are the sternum or the tibia. However, there are other options, including the radius, ulna, pelvis, clavicle and calcaneus. Whatever site is chosen, it should be easily accessible and should not interfere with procedures like spinal immobilization or CPR.4,12,24--26

Verification and Assessment of Correct IO Placement

How do you know if the IO needle is in the right place? Several methods have been described to indicate and demonstrate proper placement. Normally, with the initial placement of the device, one feels a "pop" or change in the resistance to forward movement as the needle passes from the outside, or hard part of the bone, to the soft marrow found on the inside of the bone. Once in place, the needle should "stand at attention," as the cortex of the bone holds the needle in position. Occasionally, but certainly not always, small amounts of bone marrow may be aspirated into a syringe. Once the needle is in place, fluid should be able to be infused with either a syringe or normal IV tubing (typically with a pressure bag). Regular assessment of the surrounding tissues for signs of infiltration is essential with IO infusions, just as it is for a peripherally placed IV.12,27

How Long Can An IO Stay in Place?

An IO device is typically placed to provide vascular access when the ability to promptly obtain adequate peripheral or central IV access is in question. In many cases, once a child has received a few fluid boluses, veins that had been "hidden" may suddenly reappear, enabling placement of a peripheral IV. After one of these more traditional lines is established, the IO device can be removed. Though most commonly left in place for a few hours, some IOs have been in place for as long as 24 hours without sequelae.4,28

Potential Complications of IO Access

One of the most commonly cited fears associated with IO placement is osteomyelitis. Research has shown that, with proper sterile technique during initial placement, the actual risk of this infection is only 0.6% and potentially even less if the device is removed promptly.28--30 Another common concern centers on the potential inhibition of bone growth, but this concern appears entirely unfounded. 20,29,31--32 Micro-fat emboli can occur with placement of an IO line and fluid administration; however, this has not been shown to be a clinical problem.30,33

Infiltration and subsequent compartment syndrome is a definite concern with IO infusions. If undetected, it can result in local tissue death and even loss of the limb. This is especially significant if caustic medications like dopamine were infusing.12 The key to avoiding these complications is regular and repeated assessment of the IO site and surrounding tissues. If any infiltration is detected, the IO infusion should be discontinued immediately. In addition, if an IO device insertion has been unsuccessful, or if one has been removed, it is essential that all caregivers are aware of the situation so that no further IO attempts are made on that same bone.

Effectiveness of IO vs. IV Access

When an IO is correctly placed, fluid and medications can be administered just as if an IV line was in place. The intraosseous space is a specialized area of the vascular system. Resting pressure in the intraosseous space (10--35 mmHg) is generally a value between mean arterial pressure (50--100 mmHg) and venous pressure (0--10 mmHg). Though fluid may flow to gravity into an IO line, the flow rate for bolus infusions can be optimized if a syringe or pressure bag (inflated up to 300 mmHg) is used. Utilizing these methods, flow rates in excess of 40cc/min (2,400cc/hr) can be achieved, and a pediatric 20cc/kg fluid bolus can be given over 5--6 minutes.24 A study using a sternal IO device reported a remarkable gravity flow rate of up to 80cc/min and delivery of more than 150 cc/min by syringe bolus.34

Whether it's administered by IV or IO routes, one of the key factors is the amount of time that it takes for the medication to reach the central circulation. Studies have shown that medications given via an IO infusion reach central circulation just as fast, if not faster, than when administered by standard IV access.1,4,35,36 As for which medications can be administered through the IO device, the answer is simple: Anything that can be given by IV--from blood products and analgesics to antibiotics--can be given by IO effectively.12,26,36

The ideal device or needle should be small, lightweight, reloadable, inexpensive and easily inserted under any conditions. Again, the IO technique is not advocated as a replacement for conventional IV techniques. Instead, it should be considered as a viable alternative under emergency situations in which gaining vascular access is imperative, but conditions make it extremely difficult for even the most experienced health provider to obtain IV access.4

IO Device Options

Currently, there are several different devices available for placing an IO line. These devices range from familiar manually inserted spinal needles to impact-driven devices and power drills. Prior to the creation of products specifically designed for IO access, spinal needles and "butterfly" needles had been used. When using a spinal needle, it is essential to use one that has a removable stylet or trocar, which will keep the needle from becoming plugged by tissue during initial placement.

Historically, the most popular IO needles used with pediatric patients (and in rare cases, adult patients) have been the Jamshidi/Illinois (Figures 3 and 4, Cardinal Health, McGaw Park, IL) or Sur-Fast (Figure 5, Cook Critical Care, Bloomington, IN) types. These devices are introduced by using a turning or screwing motion with sufficient downward pressure to allow the needle to bore into the bone. Recently, introduction of the next generation of IO access began with an exploration of the expanded potential patient population, an examination of IO sites beyond the tibia, and research into newer IO infusion devices.12,19,24,30,33,37--40

What's New?

Patient Population: Though commonly thought of only in the realm of resuscitation efforts for our pediatric patients under age six, intraosseous devices are now recommended for use in all age groups. The American Heart Association (AHA) Pediatric Advanced Life Support (PALS) textbook states that rescuers should "extend the use of intraosseous techniques to victims greater than six years old."41 The AHA Advanced Cardiac Life Support textbook describes intraosseous infusion as "a promising technique to establish emergency access in adult patients."19 In addition, IO devices continue to be used in nontraditional patient situations such as burns, trauma and simulated chemical/biological/nuclear disaster training.4,26

Bone Injection Gun: This spring-loaded, impact-driven intraosseous device (Figures 6 and 7) from WaisMed, Yokneam, Israel, comes in both a pediatric and an adult size. Simply pull the trigger and the needle is injected to a preset depth. Though it's most commonly used in the pediatric or adult tibia, researchers describe its use in the radius, ulna and humerus as well.9,12,26,33,39,42-45

F.A.S.T.-1: This IO device (Figure 8) from Pyng Medical Corp., Richmond, BC, Canada, is designed be placed in the sternum. A guide is placed on the upper part of the sternum to mark placement, and the device uses a "bed of needles" to control the depth. With manual pressure, the IO device is inserted into the sternum and the infusion tube is left in place.9,12,33,46

EZ-IO: The design for this IO device (Figures 9 and 10, VidaCare, San Antonio, TX) came from the experiences of orthopedic surgeons who use drills to safely enter bone. The EZ-IO is a handheld, battery-powered drill with an IO needle attached. This device allows the operator to control the pressure or force used during insertion, and thereby determine the exact depth of needle placement.47

Comparison

In the challenging prehospital environment, having alternative methods for fluid resuscitation or medication administration like IO devices could mean the difference between life and death. The newest IO devices offer some interesting alternatives to the items that we have been using. In situations where pelvic or lower-extremity injuries are common, the ability to use sites other than the tibia may be important. In addition, certain air medical services may have limited access to the patient during transport, making the placement of the F.A.S.T.-1 sternal device more attractive. The compact nature of the Bone Injection Gun offers advantages to services where size and weight are important considerations. The controlled insertion and lack of bone trauma afforded by the EZ-IO may be critical issues to others. Ultimately, the decision of which IO device(s) to carry is one that needs to be made by the individual service and its medical director, but it is encouraging that there are a number of different products available, and that developments in both pediatric and adult IO equipment continue.

Conclusion

The importance of understanding and applying the principles of IO infusion has never been stronger. The potential applications for intraosseous access have increased and we can expect more interest in and emphasis on this lifesaving technique in the foreseeable future. Both in the civilian and military environments, where time is critical and conditions can be less than optimal, IO infusion may be the access of choice.

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