VIDEOS IN CLINICAL MEDICINE
SUMMARY POINTS

Insertion of an Intraosseous Needle in Adults

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The following text summarizes information provided in the video.

OVERVIEW

Obtaining rapid vascular access is an essential step in the resuscitation of critically ill patients. Peripheral or central intravenous access may be difficult to obtain in a timely manner in such patients, especially in children and neonates but also in adult patients, in whom the vessels may be constricted. Obtaining peripheral intravenous access is especially challenging when environmental conditions are unfavorable (e.g., before a patient's arrival at a hospital, during mass casualty events, or during military operations).[1-3] Central intravenous access carries the risk of pneumothorax and arterial injury and requires a high level of expertise; in most instances, it is not possible to perform the procedure in a prehospital setting.[1] The insertion of an intraosseous needle provides an alternative route for vascular access in these circumstances; it is also used after other approaches have failed. Although intraosseous needle insertion was originally performed in the resuscitation of pediatric patients, it has gained acceptance for use in adults, especially since the advent of mechanical insertion devices.[1,3-9] The video focuses on intraosseous insertion in adult patients.

The most recent guidelines from the Advanced Cardiac Life Support Certification Institute, published in 2010, recommend the intraosseous route over the endotracheal route for the administration of fluids and medications in adult patients in whom intravascular access is not available.[6] The primary advantages of the intraosseous route are speed of access and reliability.[3]

INDICATIONS

Intraosseous access is indicated for patients in whom there is an urgent need for vascular access in order to provide fluid resuscitation or medication delivery and in whom conventional venous access is not readily available. Cardiac arrest, shock, trauma, extensive burns, severe dehydration, and status epilepticus are possible clinical scenarios in which intraosseous access may be needed.[2] Intraosseous access has been used successfully for situations in which adverse environmental conditions make it very difficult to obtain intravenous access (e.g., search-and-rescue and military operations).[1,2] This technique is also useful when central venous access is not feasible because of either lack of provider expertise or lack of equipment (e.g., in prehospital settings).[1]

Crystalloids, colloids, blood products, and many medications — including drugs used for resuscitation and vasopressor infusions — can be administered through the intraosseous route,[3] and the doses are the same as those used when intravenous access has been established.[6] In addition, in the critically ill patient,

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N Engl J Med 2014;370:e35.
DOI: 10.1056/NEJMvcm1211371

a sample can be drawn from the intraosseous space for laboratory testing (e.g., blood typing, measurement of hemoglobin level, serum chemical analysis, and blood gas analysis). The blood gases from marrow samples are typically at an intermediate level between arterial and venous levels.[10] Some discrepancies between intraosseous and venous samples have been found in alkaline phosphatase, lactate dehydrogenase, and hemoglobin levels. When intraosseous samples were collected after the infusion of fluids through the site and after 30 minutes of cardiopulmonary resuscitation, hemoglobin levels were shown to be lower than the levels in the central circulation.[11]

CONTRAINDICATIONS

Since intraosseous insertion is used only in emergencies, there are few contraindications to placement. Contraindications include ipsilateral fractures, previous attempts at ipsilateral intraosseous access, local vascular injuries, cellulitis, and burns.[2,3] Ipsilateral fracture or previous attempts at intraosseous access can lead to fluid extravasation and compartment syndrome and should thus be avoided.[2,3] Intraosseous insertion should be avoided in patients with a high risk of fracture (e.g., patients with osteogenesis imperfecta, severe or advanced osteoporosis, or coagulopathies).[2]

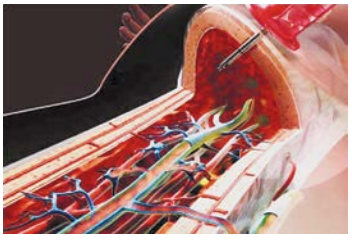

Figure 1. Drainage of the Medullary and Venous Sinusoids into the Central Venous Channel, with Penetration of the Intraosseous Needle into the Medullary Cavity.

ANATOMY

The medullary cavity is a highly vascular structure that functions as a noncollapsible vein capable of accepting a large volume of fluid and medications and rapidly delivering them to the central circulation (Fig. 1). The medullary venous sinusoids drain into a central venous channel, which exits the bone in the form of emissary and nutrient veins. The rate of infusion is limited by the size of the medullary cavity and the diameter of the intraosseous needle.

SITE SELECTION

A number of sites can be used for intraosseous needle insertion in an adult, such as the proximal tibia, the distal tibia, the humerus, the distal femur, the sternum, the calcaneus, and the styloid of the radius.[1-3] When a mechanical insertion device is used, the anteromedial surface of the proximal tibia is the preferred site of insertion because it is easy to locate, presents a flat and wide surface for insertion, and has minimal subcutaneous layers overlying the bone.[3] In addition, this site has the benefit of being distant from the patient's chest and thus will pose minimal interference with cardiopulmonary resuscitation. If it is not possible to obtain intraosseous access through the proximal tibia, the humeral head and distal tibia are alternative sites.

If the intraosseous needle is inserted manually, the medial aspect of the distal tibia is the preferred site in adult patients because of its thin bone cortex and overlying tissue.[2] A substantial amount of force and a large-bore needle are required to manually penetrate the bone.

The sternum is another alternative site.[3] A specific mechanical system for intraosseous needle insertion system facilitates needle insertion with minimal risk of perforation or infection of mediastinal structures. Although the thin bone cortex makes this the easiest site for manual insertion in adults, it does carry a small risk of perforation of mediastinal structures and is thus not favored. Additional impediments to use include risk of dislodgement during cardiopulmonary resuscitation and interference with cardiopulmonary resuscitation. This technique is not described in the video.

PREPARATION FOR MECHANICAL INSERTION

The following items should be assembled in preparation for the drill-based insertion: chlorhexidine or iodine solution for site preparation, sterile gloves, sterile towels for draping the site, a kit for mechanical device insertion, a 10-cc syringe for aspiration and infiltration, a solution of 1% lidocaine for analgesia if the patient is conscious, standard Luer-Lok tubing for the delivery of fluids or medication, a pressure bag if large volumes of fluid need to be administered through the intraosseous system, and gauze and tape for securing the device.

In adults, the use of mechanical drill-assisted insertion devices facilitates intraosseous needle insertion, although manual insertion is also possible. Mechanical devices developed for intraosseous access placement and approved by the Food and Drug Administration are the FAST-1 Intraosseous Infusion System (Pyng Medical) for sternal intraosseous access, the EZ-IO drill (Vidacare), and the Bone Injection Gun (Waismed).[9] The use of a drill-assisted mechanical insertion device is described in the video.

INTRAOSSEOUS NEEDLE INSERTION WITH A MECHANICAL DEVICE

Obtaining intraosseous access is an emergency procedure. Consequently, it is rarely possible to obtain informed consent before performing the procedure. If possible, explain the risks and benefits of the procedure to the patient or the next of kin; otherwise, proceed with insertion.

When a mechanical device is used, the proximal tibia is the preferred site in adults. Secondary sites are the distal tibia and the humeral head.

Position the patient's leg in slight flexion by placing a rolled towel under the knee. Don sterile gloves, expose and clean the site with chlorhexidine or iodine solution, and then drape the site in a sterile fashion. If the patient is conscious, infiltrate the skin and subcutaneous tissues and the periosteum with 20 to 30 mg of 1% lidocaine.

Identify the tibial tuberosity. The desired insertion site is the flat medial surface of the tibia, medially one finger's width away from the tibial tuberosity (Fig. 2). Stabilize the leg with your nondominant hand. Holding the drill in your dominant hand, position the needle tip at a 90-degree angle to the surface of the bone. Press and hold the trigger and gently guide the needle through the tissues, avoiding excess pressure. A sudden loss of resistance indicates that the needle has penetrated the cortex and has reached the medullary cavity.

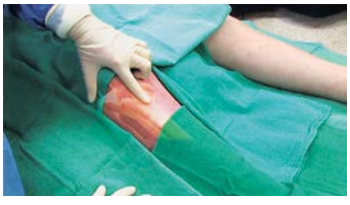

Figure 2. The Desired Site for Mechanical Intraosseous Needle Insertion.

The ideal mechanical insertion site is the flat medial surface of the tibia, medially one finger's width away from the tibial tuberosity.

Remove the stylet and connect the needle to a 10-cc syringe with standard Luer-Lok tubing. If the needle is correctly placed within the marrow cavity, it should be possible for it to stand upright without support. Aspiration of blood and marrow confirms adequate placement of the needle, but it is not always possible to aspirate marrow, even with adequate placement. Obtain confirmation of placement by infusing a 10-cc bolus of saline solution through the syringe; the fluid should flow easily, with no resistance. If the fluid does not flow, select another insertion site.

After correct placement has been confirmed, the test syringe can be disconnected and the intraosseous needle can be connected to regular infusion tubing. Fluids can be infused by means of gravity, but infusing fluids through a pressure bag produces better flow rates. A pressure bag should be used in patients requiring resuscitation, once you are certain that the needle has been correctly placed and is functioning. If the patient is conscious, anesthetize the marrow cavity by infusing 20 to 40 mg of 1% lidocaine before initiating the infusion. While infusing fluids, watch carefully for extravasation and increased calf circumference. The

needle and tubing should be secured to the leg with tape, and the leg should be immobilized to prevent dislodgement of the needle.

To remove the catheter, disconnect the intravenous tubing and attach a sterile syringe to the hub. Stabilize the leg, and gently pull back while rotating the needle clockwise.

PREPARATION FOR MANUAL INSERTION

The following items should be assembled in preparation for the manual insertion of an intraosseous needle: chlorhexidine or iodine solution for site preparation, sterile gloves, sterile towels for draping the site, an intraosseous needle, a 10-cc syringe for aspiration and infiltration, a solution of 1% lidocaine for analgesia if the patient is conscious, standard Luer-Lok tubing for the delivery of fluids or medication, a pressure bag if large volumes of fluid need to be administered through the intraosseous system, and gauze and tape for securing the device.

Several different types of needles can be used in manual intraosseous insertion. They all have in common the presence of a stylet, which improves the likelihood of cortical penetration and prevents plugging of the needle cavity with bone spicules during insertion.[12] They range in size from 13-gauge to 20-gauge and have variable lengths and handle types. A depth marker or an adjustable sleeve allows for better control of penetration depth. A shorter shaft and a smaller handle are desirable features, since they allow for better control.[2]

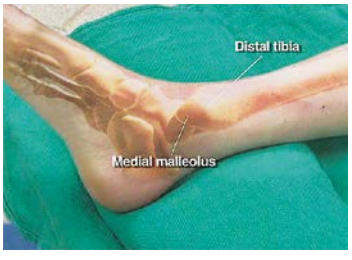

Figure 3. The Desired Site for Manual Intraosseous Needle Insertion.

The preferred site for manual insertion in adults is the medial aspect of the distal tibia, just proximal to the medial malleolus.

MANUAL INTRAOSSEOUS NEEDLE INSERTION

The preferred site for manual insertion in adults is the medial aspect of the distal tibia, just proximal to the medial malleolus (Fig. 3). Position the leg so that it is in slight flexion and externally rotated at the hip. As described earlier for mechanical insertion, use sterile technique and appropriate analgesia. Stabilize the leg with the nondominant hand. Hold the needle in the palm of the dominant hand and position it at a 90-degree angle to the long axis of the bone. Advance the needle through the bony cortex with a twisting or rotating motion and steady pressure; you will encounter a great deal of resistance.

A sudden loss of resistance indicates that the needle has penetrated the cortex and reached the medullary cavity. Remove the stylet and connect a 5-cc or 10-cc syringe to the needle. Obtain confirmation of placement by infusing a 10-cc bolus of saline solution through the syringe; the fluid should flow easily, with no resistance. If the fluid does not flow easily, the needle can be repositioned by pulling back slightly, but if further resistance is encountered, the needle should be removed and a new site selected. You can avoid through-and-through penetration of the bone by using the depth markings on the needle and by placing the index finger about 1 cm from the bevel of the needle. Secure the needle with bulky gauze dressing and tape.

COMPLICATIONS

Complications can occur during the course of the procedure or even after successful placement of the intraosseous needle. Notable morbidity has been quoted at less than 1% for all occurrences combined.[4] The most common complication of intraosseous needle insertion is fluid extravasation resulting from through-and-through penetration of the bone or from incomplete insertion of the needle. If extravasation occurs, the needle should be removed and pressure should be applied to the site. Compartment syndrome is a rare but possible complication of fluid extravasation that may occur when a needle has been placed incorrectly. Bone spicules may cause

blockage of the needle; to prevent blockage, the line should be flushed with 3 to 5 cc of saline every 15 minutes.

Other complications during insertion include subcutaneous or subperiosteal infiltration due to incomplete insertion. Fracture of the long bones has also been reported after intraosseous needle insertion; the risk increases if the patient has a disorder associated with a predisposition to bone fragility.[4] Dislodgement of the needle and infiltration of large amounts of fluid in the interstitial space may lead to compartment syndrome.

Despite adequate placement of the needle, the following complications may also occur: infection (cellulitis or osteomyelitis), fat embolus (reported in animal models but not of clinical significance), local hematoma, pain, and compartment syndrome.[4,13] The reported rate of infection is lower than 3%, and a large literature review indicates that the incidence of procedure-related osteomyelitis is 0.6%.[14] Local inflammation of the bone or necrosis of the skin at the insertion site may also occur; it is more common when hypertonic or sclerosing agents are infiltrated.[2]

SUMMARY

Intraosseous needle insertion is used as a temporary measure when intravascular access cannot be achieved through peripheral or central venous routes. The intraosseous needle may remain in situ for 72 to 96 hours, but it is best removed within 6 to 12 hours, as soon as an alternative site of intravascular access has been established. The intraosseous route provides fast and reliable vascular access in emergency medical situations. The use of the appropriate technique will ensure that the procedure is performed as safely and effectively as possible.

No potential conflict of interest relevant to this article was reported.
Disclosure forms provided by the authors are available with the full text of this article at NEJM.org.

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