

Intraosseous cannulation in children

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Abstract

In an emergency situation when intravenous (IV) access cannot be rapidly achieved, the intraosseous (IO) route is recommended in order to infuse medications and fluids. Specifically designed needles make this technique quick, easy and reliable. This article describes the anatomy and physiology relevant to IO cannula insertion as well as indications and contraindications for IO use. The variety of devices and the techniques for their use in the paediatric population are discussed.

Keywords Cannulation; children; fluid; intraosseous; intravenous; resuscitation

Royal College of Anaesthetists CPD Matrix: 1B04, 2A05, 2D01, 2D03, 2D04, 3D00

Introduction

Intraosseous (IO) cannulation involves accessing the medullary cavity of long bones to allow the infusion of fluids and administration of drugs into the venous system. As well as the administration of drugs and fluids, samples of bone marrow can be aspirated and used for blood testing. IO cannulation has been described since the 1920s as a technique for rapid vascular access.¹ With the increase in availability of more advanced equipment for central and peripheral venous access in the 1950s the use of the IO route dwindled. It is however now well recognized again as an alternative method for administration of venous fluids and drugs in an emergency situation.

Anatomy and physiology

The IO route provides access to the central venous system via the marrow cavity of long bones. As bones are non-compressible this marrow cavity remains patent even in shocked, peripherally shut down patients, thus providing a rapid way to administer drugs and fluids.

The proximal and distal ends of long bones are known as the epiphyses. The marrow cavity within the epiphysis consists of a large network of blood vessels known as Haversian canals (running vertically) and Volkmann's canals (running horizontally). These blood vessels drain into a single central venous canal which in turn empties via the intramedullary or emissary vessels directly into the venous circulation. The tibial marrow

Learning objectives

After reading this article, you should be able to:

- state the indications and contraindications for intraosseous cannulation in children
- describe the technique for intraosseous cannulation in children
- list the complications associated with intraosseous cannulation in children

space is the preferred site for IO cannulation in children; the tibial intramedullary vessels empty directly into the popliteal vein, which in turn drains into the femoral vein. The epiphysis is the preferred site of insertion of IO needles as the compact bone is relatively thinner and there is more cancellous or spongy bone present allowing for easier access to the marrow cavity.

At around five to six years of age the red vascular marrow of the infant is replaced by relatively less vascular yellow marrow. The IO route was often reserved for children under the age of 6 for this reason. However, although the marrow cavity of older children and adults is harder to cannulate due to the increase of hard compact bone, the absorption of drugs and fluids still occurs, making the IO route suitable for use in all ages.

Fluids and medications

Any medication or fluid that can be given via the central venous route can also be given via the IO route; including all resuscitation, anaesthetic and vasoactive drugs. The Advanced Paediatric Life Support (APLS) guidelines state that IO access is the preferred route for administration of adrenaline when IV access cannot be obtained in cardiac arrest.² The venous plexuses of long bones drain into the central circulation at a rate comparable to central venous access, with onset times of drugs also similar between the two routes of administration.¹ Fluid resuscitation can also be accomplished via the IO route, with flow rates of up to 1–3 litres per hour via tibial access or 5 litres per hour via humeral access. Due to the intrinsic pressure of the intraosseous space, infusions commonly do not flow effectively with gravity alone and need to be administered under pressure. The marrow cavity may also act as a depot for some drugs with consequent prolonging duration of action.

Diagnostic tests

Blood samples drawn immediately after intraosseous cannulation can provide rapid samples for accurate laboratory and blood bank analysis to aid in resuscitation. The marrow and blood mixture that is aspirated following initial needle insertion reliably correlates with the values that are obtained from a peripheral venous sample, including samples required for cross match. The exceptions are carbon dioxide and platelet measurements (which may be lower in intraosseous samples), and the leukocyte count which may be higher.³ Sodium, potassium and calcium values obtained from blood and marrow mixtures may also be inaccurate. Blood gas measurements from intraosseous aspirates correspond with arterialized capillary blood samples, with the values obtained sitting somewhere between arterial and venous

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values;³ however, it is important to note that some blood gas analyser machines may be damaged by particulate matter within the marrow samples, and so local agreement should be sought prior to testing samples in this way.

Indications

In emergency and life-threatening situations, establishing venous access quickly is essential and often difficult. The Advanced Life Support Group recommends IO cannulation for circulatory access in cardiac arrest and when intravenous access is difficult or takes longer than 1.5 minutes to establish in the paediatric population. IO cannulation has also proved valuable for patients that have had multiple vascular access devices in the past as well as recreational intravenous drug abusers.

Contraindications

Absolute

- Trauma to the bone at or proximal to the insertion site
 - allows extravasation of fluids and therefore a risk of compartment syndrome.
- Bone diseases including:
 - osteogenesis imperfecta
 - osteoporosis
 - osteomyelitis.
- Infection of the tissues overlying the insertion site.

Relative

- Previous orthopaedic surgery near to the insertion site (prostheses, tibial nails)
 - could lead to unpredictable flow due to disruption of bone matrix.
- Previous IO cannulation at the same site within the preceding 24–48 hours.
- Inability to locate landmarks.
- Clotting disorders.

Access sites

Proximal tibia

This is the preferred site of access in infants and children. The leg should be positioned with a firm support behind the knee, for example, a rolled towel. The anteromedial surface is accessed below and just medial to the tibial tuberosity. In newborns, the needle should be inserted 1 cm below the anterior tibial tuberosity and aimed in a slight posterior and inferior direction to avoid damaging the growth plate. In children and adults, the needle is inserted 2 cm below the tibial tuberosity and 1 cm medially on the tibial plateau.

Distal tibia

The insertion site is on the flat central aspect of the bone, which is located 2–3 cm proximal to the medial malleolus. The needle is inserted at 90 degrees to the skin.

Humeral head

With the elbow bent and the patient's hand over their umbilicus, locate the surgical neck of the humerus by palpating along the humerus from the elbow until the greater tubercle is felt. The insertion site is 1 cm above this and 2–3 cm lateral to the biceps

tendon. The needle is inserted at a 45 degree angle and aimed towards the opposite scapula. This technique is recommended for adults and older children and may be a superior site due to superior flow rates, drug delivery and ability to manage infusion pain. The greater tubercle may be difficult to palpate in younger children as it is poorly developed.

Distal femur

The distal femur is only recommended for children under 6 years of age. With the leg fully extended at the knee, palpate the patella. The ideal insertion point is 2 cm above the patella and 1–2 cm medial to the anterior midline in order to avoid the patella tendon (proximal placement is important to avoid growth plates in younger patients). The leg should be immobilized until the cannula is removed as movement at the knee may cause the quadriceps tendon to displace the cannula.

Sternum

This route is commonly used in pre-hospital emergency care for adults. The needle is inserted at a 90 degree angle to the skin, 2 cm below the sternal notch. To access the sternum a special device designed for sternal use must be used. This technique is not advised for patients less than 12 years of age due to the risk of injury to the great vessels.

Common insertion technique for all devices

- Explain the procedure to patient and relatives.
- Obtain skilled assistance as needed.
- Universal precautions.
- Identify site and position appropriately, manually stabilizing the bone (ensuring the hand is not placed under the limb).
- Clean site and administer local anaesthetic in the conscious child.
- Once the needle is stable (unsupported) within the cortex, remove the stylet and aspirate blood marrow.
- Syringe bolus: flush the catheter with 10 ml of normal saline (using lidocaine in the conscious patient for analgesia).
- Apply stabilizer dressing.
- Ensure the needle is flushed with at least 10 ml of fluid after drug administration.
- Clear documentation of the procedure in the patient notes.
- Frequent assessment of the IO site for signs of extravasation.

Types of devices (Figure 1)

There are a number of commercially available specialized single use needles designed for IO use. These needles have specialized handles to aid insertion and short needle shafts to minimize the risk of dislodgment, along with a stylet to prevent blockage of the needle during the insertion process. The hubs of the needles have Luer lock connections to connect to standard IV tubing.

Manual trocar: The needle comes in a 16 G diameter which is appropriate for all paediatric patients. These manual devices require significant insertion force and have a steep learning curve. They are commonly used in paediatric patients for lower limb access sites and the main advantage lies in the lower cost of

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