

Intraosseous infusion

What is intraosseous infusion?^[1]

Intraosseous access has received a great deal of attention as an effective first alternative to failed or delayed peripheral or central intravenous access in emergency situations. The technique involves the placement of a vascular device with the tip of the intraosseous catheter in the bone matrix. Crystalloids, colloids, or medications delivered through this catheter immediately infuse into the systemic circulation via the bone marrow cavity.^[2]

Intraosseous infusion has few contra-indications and the success rate is very high, whilst the rate of complications is very low. The use of intraosseous infusion was restricted to use in the resuscitation of children (overtaking saphenous vein cutdown) and military medicine for a number of years but is now increasingly being used in adults.^[3] Indeed, intraosseous infusion is now preferred over the endotracheal route to administer drugs during advanced life support in adults (the endotracheal route being no longer used).^[4]

However, one review found that intraosseous access in out-of-hospital cardiac arrest is related to poorer outcomes in terms of return of spontaneous circulation and survival at hospital discharge.^[5]

In the neonate intraosseous access may be easier and quicker than umbilical vein catheterisation in an emergency.

Indications

Intraosseous access can be considered clinically appropriate on the basis of a short-term (up to 24 hours) need for patients.^[2] The current guidelines of the Advanced Adult Life Support stipulate that intraosseous access should be used if establishing a peripheral venous access for cardiopulmonary resuscitation (CPR) would involve delays.^[4]

Guidelines also state that, during CPR in children aged younger than 6 years, intraosseous access should be obtained if there is inability to achieve reliable venous access after three attempts or 90 seconds, whichever comes sooner. Intraosseous access has the same benefits in children aged over 6 years but access to the anterior tibial marrow is more difficult and other sites such as the lower femur, iliac crest or sternum should be considered.

- It can be considered in other situations too where there is circulatory collapse, as in severe dehydration and [diabetic ketoacidosis](#).^[6]
- It also gives access for rapid delivery of fluids in children with burns.
- It can even be used in neonates, although is not often required because of easy umbilical venous access.^[7]
- It is possible to give all resuscitation fluids and drugs except bretylium.
- It is possible to achieve high flow rates especially if using a syringe to infuse fluid.
- It can be used to administer blood.
- It can be used to administer drugs and achieves adequate plasma concentrations in a time comparable with injection through a central venous catheter.^[4]
- It also enables withdrawal of marrow for venous blood gas analysis and measurement of electrolytes and haemoglobin concentration.^[4]

Contra-indications

Intraosseous access should be avoided in the following situations:^[2]

- Fractures in the same extremity as the targeted bone.
- Previous surgery involving hardware in the bone targeted for intraosseous access.
- Infection at the insertion site or within the targeted bone.
- Local vascular compromise.

- Previous failed intraosseous access within 24 hours in the targeted bone.
- Inability to locate the landmarks.

Bone disease such as osteogenesis imperfecta, osteopetrosis and severe osteoporosis may be contra-indications depending on the device.

Types of devices used for intraosseous infusion

Various methods of needle placement can be used for intraosseous access:^[2]

- Manually inserted needles are hollow steel needles with removable trocars that prevent bone fragments from plugging the needles during insertion. The steel manual needles are limited by the difficulty accessing dense adult bone.
- Impact-driven: two types of devices are impact-driven. Both of these devices must be appropriately stabilised to prevent injury to the patient or the healthcare worker:
 - One device, originally designed for sternal access, has several needle probes to locate the depth of the sternum accurately. When pressure is applied, the central needle extends into the sternal medullary cavity. A possible limitation is a lack of access to the sternum in resuscitation situations.
 - The other type uses a spring-loaded injector mechanism that fires the intraosseous needle into the medullary space of the tibia.

- Battery-operated, drill-based:
 - Designed to access the intraosseous space to an appropriate depth.
 - It consists of a driver and a needle set designed for insertion into the intraosseous space.
 - Different needle sizes are used depending on the patient's age, weight and tissue depth over the landmarks.
 - The precise needle-to-bone ratio allows efficient insertion and is designed to minimise trauma to the bone during insertion.
 - Some drills are not recommended for young infants (eg, weight less than 3 kg) but the needle may be useful for the manual technique.

The 'bone injection gun' (BIG) and similar devices have helped to improve and increase the use of this route.^[8] It may be a little quicker to use and it may even be suitable for mass use in chemical warfare where there are many casualties needing vascular access and staff are encumbered by personal protective equipment (PPE) clothes.^{[9] [10] [11]} The powered device is also safe for use in children.^[12]

Intraosseous infusion technique

The following description is for the manual insertion of a needle into the tibia.

- Ideally this should be a sterile procedure using a specific needle but it is possible to use a bone marrow aspiration needle or any 14-20 gauge needle with an internal stylus in an emergency.
- Palpate the tibial tuberosity. The site for cannulation lies 2-3 cm below this tuberosity on the anteromedial surface of the tibia. An insertion site of at least 10 mm distal to the tibial tuberosity is recommended to avoid injury to the epiphyseal growth plate and to ensure ease of insertion.^[13]
- Use sterile gloves with an aseptic technique and a sterile needle. Clean the skin. Placing a bone marrow needle without using a sterile technique increases the risk of osteomyelitis and cellulitis.

- Inject a small amount of local anaesthetic into the skin and continue to infiltrate down to the periosteum. This is unnecessary in an unconscious patient.
- Flex the knee and put a firm support behind the knee.
- Hold the limb firmly above the site of insertion, usually at the level of the knee.
- Insert the intraosseous needle perpendicular to the skin and through subcutaneous tissue until bone is felt.
- Advance the needle, using a drilling motion until a 'give' is felt. This occurs when the needle penetrates the cortex of the bone. Stop inserting further.
- Remove the trochar. Confirm the correct position by aspirating blood, using a 5 ml syringe.
- Inject a test bolus of fluid – eg, 10 ml 0.9% normal saline.
- Check that the limb does not swell up and that there is no increase in resistance.
- If the tests are unsuccessful, remove the needle and try the other leg.
- Connect to an infusion set with a short extension and three-way tap to reduce traction on the needle. Immobilise the access with a dressing and tension relief with adhesive tape between the leg and the infusion set.

Correct placement is further confirmed by:

- A sudden loss of resistance on entering the marrow cavity. This is less obvious in infants, as they have soft bones.
- The needle remaining upright without support. Because infants have softer bones, the needle will not stand as firmly upright as in older children.
- Fluid flowing freely through the needle without swelling of the subcutaneous tissue.

Change to venous access as soon as adequate resuscitation is achieved.

Complications

Complications from intraosseous access are rare:

- Pain can be significant and this should be borne in mind when using the technique. Adequate local anaesthetic should be used in conscious patients. One report suggested pain from use of this technique was more significant than the injuries being treated in some patients.^[14]
 - Fractures and osteomyelitis after long-term use or when hypertonic solutions have been used.
 - Fat embolism is less likely in children than in adults and has minimal clinical consequences.
 - Local extravasation of fluids, due to incomplete penetration of the needle into the cortex, intraosseous infusion into a fractured limb, or perforation of the bone, may lead to compartment syndrome.
 - Follow-up in neonates has excluded concerns about injury to growing bone and the growth plate.
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Further reading

- [Astasio-Picado A, Cobos-Moreno P, Gomez-Martin B, et al](#); Clinical Management of Intraosseous Access in Adults in Critical Situations for Health Professionals. *Healthcare (Basel)*. 2022 Feb 14;10(2). pii: healthcare10020367. doi: 10.3390/healthcare10020367.
- [Intraosseous access](#); The Royal Children's Hospital Melbourne, Clinical Practice Guidelines

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Last updated by: Dr Colin Tidy, MRCP 21/09/2022	
Peer reviewed by: Dr Hayley Willacy, FRCGP 21/09/2022	Next review date: 20/09/2027

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