

## **Intraosseous Vascular Access and Lidocaine**

Intraosseous (IO) needles provide access to the medullary cavity of a bone. It is a technique primarily used in emergency situations to administer fluid and medication when intravenous (IV) access proves difficult or impossible to establish. The technique was first discovered in 1922 when C.K. Drinker MD of Harvard University confirmed that fluids infused into the bone marrow were rapidly absorbed into the central circulation.

IO access is effective for resuscitation since the medulla of the bone is essentially a non-collapsible component of the cardiovascular system. During hypovolaemic and low cardiac output states, peripheral veins collapse and become difficult to cannulate whereas the bone medulla remains 'open'. IO fluids and drugs are rapidly absorbed through the medulla's dynamic and rich venous plexus and gain access to the central circulation within seconds even in physiological shock. Any medicine, fluid or blood product that can be administered through a peripheral IV line can be administered via the IO route. Laboratory analysis of samples obtained through IO access show good correlation with venous blood for several common tests including haemoglobin, urea, creatinine, glucose and chloride.

Although the benefit of IO access was widely recognised, technical difficulties often led to reluctance to attempt in actual resuscitation scenarios. IO access was primarily seen as a technique used during resuscitation of children in decompensated or cardiac arrest states and was therefore taught on paediatric life support courses. A range of new devices however provide an easy to perform, reliable method of establishing IO access and ensures this technique is accessible to a greater number of both adult and paediatric patients.

### **Current Recommendations**

The European Resuscitation Council:

'Venous access can be difficult to establish during resuscitation of an infant or child: if attempts at establishing intravenous (IV) access are unsuccessful after one minute, insert an intraosseous (IO) needle instead.'

The UK Resuscitation Council:

'If intravenous access cannot be established within the first 2 minutes of resuscitation, consider gaining IO access. Intraosseous access has traditionally been used for children because of the difficulties in gaining intravenous access, but this route has now become established as a safe and effective route for drug and fluid delivery in adults too. Tibial and humeral sites are readily accessible and provide equal flow rates for fluids. Intraosseous delivery of resuscitation drugs will achieve adequate plasma concentrations.'

The European Paediatric Life Support Course Manual (2<sup>nd</sup> edition):

Intraosseous access is the first choice in cardiac arrest / decompensated failure states or resuscitator taking greater than 90 seconds or more than 3 attempts at securing peripheral venous access in a sick child.

The American Heart Association ACLS:

Intraosseous access is the first alternative to intravenous in adult cardiac arrest patients.

### **UK Hospital Trusts**

A growing number of UK Hospital Trusts are purchasing IO devices and as experience is gained, the indications for use are extending to include acutely sick or injured adult patients along with intravenous drug abusers and obese patients for whom vascular access is required for general anaesthesia. The advantages of the IO route are:

- *it provides a rapid and safe method of securing vascular access in an emergency or electively in patients with difficult to cannulate peripheral or central veins;*
- *multiple IO needle insertion devices can be stored in key locations to ensure rapid access to equipment; and*
- *it is cost-effective with a reduced potential for contributing to hospital acquired infection when compared to central lines.*

### **IO Infusion Pain in the Conscious Patient**

Use of the IO route in the conscious patient creates a new challenge due to the presence of numerous sensory receptors within the non-collapsible *and* non-expandable marrow cavity. Although the *insertion* of the IO needle itself is described as no more painful than an 18 gauge intravenous cannula, administration of IO fluids and medication can rapidly increase cavity pressure. This may become uncomfortable or painful and can restrict attempts at providing effective resuscitation.

A number of case reports and other papers have been published since 2005 citing the use of preservative free lidocaine 2% to decrease pain associated with intraosseous infusion in the conscious patient. In order to prospectively address this issue and to provide clear guidance, I reviewed the current literature believing that an objective assessment at this stage would benefit the largest number of patients in the long-term. Without clear guidance, clinicians may be forced to abandon use of the IO route during resuscitation of the conscious patient with the potential for limited care to result.

## Lidocaine and the Intraosseous Route

Lidocaine (lignocaine) is a commonly used amide local anaesthetic and anti-arrhythmic drug. Although regimens are presented in the BNF/c for neonates to adults, lidocaine is not licensed for intravenous use in infants under 1-year. The BNF/c quotes the following doses:

*For local anaesthesia:*

- Neonate to 12 years old up to **3 mg/kg** repeated not more often than every 4 hours.
- Child 12 to 18 years up to **200 mg** repeated not more often than once every 4 hours.
- Adult maximum dose **200 mg**.

*For anti-arrhythmic effects:*

- Neonate to 12 years old **0.5-1 mg/kg** by injection followed by infusion or repeated doses of 0.5-1 mg/kg at intervals of not less than 5 minutes to a **maximum of 3 mg/kg**.
- Child 12 to 18 years **50-100 mg** by injection followed by infusion or repeated doses of 50-100 mg at intervals of not less than 5 minutes to a **maximum of 300 mg** in 1 hour.
- Adults **50-100 mg** followed by infusion or repeated once or twice at a dose of 50-100 mg at intervals of not less than 10 minutes.

The maximum adult dose of 200 mg (local anaesthesia) or 300 mg (anti-arrhythmic) equates to a dose of **2.5 – 3.75 mg/kg** for an 80 kg individual.

The guideline advises users to administer preservative free lidocaine through the IO needle in order to provide analgesia for the conscious patient prior to receiving IO medication or infusion. The IO route equates to vascular administration so it is essential that recommendations are within the dose range for IV administration and are logical when compared to the doses recommended for local analgesia. The guideline displays absolute drug *volumes* and avoids dose ranges to ensure maximum clarity at the point of administration.

The current literature relating to IO lidocaine can be summarised as follows:

- Preservative free lidocaine 2% (PFL2%) is currently the drug of choice for preventing IO flush and infusion pain.
  - *It is acknowledged that the use of lidocaine is unlicensed for the vascular route in infants and this recommendation is off-label for all ages.*

- The initial dose of PFL2% should be given prior to a 10 ml Sodium Chloride 0.9% (SC0.9%) flush. Consider a lower flush volume in younger children and infants.
  - *The initial guideline dose for children and adults is 0.5 mg/kg. This is presented as the volume of 2% preservative-free lidocaine to be given IO. All volumes quoted can be easily administered using the appropriate sized intravenous syringe.*
  - *The PFL2% initial bolus should be given 'slowly' to ensure it has time to exert its effect on the nervous tissue within the medulla of the bone.*
  
- The SC0.9% 'flush' is of high pressure to 'open up' the cavity and should be given over 5 seconds after the initial PFL2% dose.
  - *A second post-flush lidocaine dose of 0.25 mg/kg should then be given to maximise analgesic distribution in the now fully expanded marrow cavity. The same principals apply to this second dose as detailed above.*
  
- Existing cautions and contraindications apply and are listed in the guideline:
  - *Hypovolaemia is listed in the BNF/c as a contra-indication although this needs to be assessed in the context of this proposal. If vascular access is not obtained in a difficult to cannulate acutely sick patient then harm will result. Although IO lidocaine administered to a patient with hypovolaemia may theoretically cause harm, the benefit under such circumstances is likely to outweigh the risk. Hypovolaemia is therefore not listed as a contra-indication within the guideline.*
  - *The proposal highlights the need to observe for side-effects during administration. The risk of side-effects is minimised through slow administration which also aims to keep the lidocaine within the marrow cavity for maximum effect.*
  
- The order of administration is: withdraw samples – lidocaine (1) – flush – lidocaine (2) – infusion/drugs.
  - *The initial lidocaine dose essentially becomes the first 'flush' so signs of IO needle misplacement and extravasation need to be sought at this stage. Extravasation of lidocaine will not harm the patient but will signify that the IO needle needs to be re-sited.*
  - *The definition of 'slow' is 1 to 2 minutes for the initial bolus and 30 seconds for any subsequent doses.*

- *The patient should be monitored clinically during administration of PFL2%. Consider use of ECG monitoring in patients with additional risk factors for arrhythmias.*
- If further analgesia is required, additional doses of 0.25 mg/kg may be given at a frequency of once every 45 minutes.
  - *This decision regarding the timing of additional doses was established following the literature review and after discussion with doctors experienced in the use of this technique in pain aware patients.*

The initial doses of IO lidocaine equates to a maximum of 0.75 mg/kg given over 1½ to 2½ minutes. This is below the BNF/c maximum for both local anaesthetic and anti-arrhythmic indications and in many cases is below that stated for a single dose. In addition to the licensed indications for lidocaine, its use has also been advocated in attenuating the pressor response to tracheal intubation and extubation. Studies have been published citing intravenous bolus doses of between 1 and 2 mg/kg being administered without side-effects and it is therefore *likely* that the doses proposed in this guideline will be safe.

Additional doses of IO lidocaine may be required for persistent or recurring pain. In order to prevent significant drug accumulation, the guideline advises a maximum of 0.25 mg/kg every 45 minutes. Calculation of the cumulative effect of additional doses based upon a lidocaine elimination half-life of 100 minutes shows that toxic levels are unlikely to be reached in clinical practice. The doses quoted are therefore likely to be safe when compared to the much higher doses used for arrhythmia, local infiltration and attenuation of the response to tracheal intubation. The recommended *volumes* of preservative free 2% lidocaine in the guideline are:

Initial dose:	0.5 mg/kg	= <b>0.025 ml/kg</b>
Subsequent dose(s):	0.25 mg/kg	= <b>0.0125 ml/kg</b>

For maximum accuracy, the guideline recommends that 1 ml intravenous syringes with 0.01 ml divisions are used for volumes less than 1 ml, 2.5 ml with 0.1 ml divisions for volumes between 1 and 2.5 ml and 5 ml syringes with 0.2 ml divisions for volumes between 2.5 and 5 ml. When an exact dose calculation results in a difficult to administer volume, rounding *down* to the nearest 0.01 – 0.2 ml occurs. Clearly the volumes for a 3 to 4 kg neonate will be very small and may lead to difficulties in accurate administration. Volumes of 1% preservative free lidocaine have therefore also been calculated and displayed.

**Dr Richard Hixson (May 10<sup>th</sup>, 2011).**