WORKSHEET for Evidence-Based Review of Science for Emergency Cardiac Care

Worksheet author(s)
William A. Engle, MD

Date Submitted for review:
April 28, 2009

Clinical question.

Suggested Outcome of interest: Success of the intraosseous route for intravascular infusion of medications and fluids in neonates requiring resuscitation.

Specific Clinical Question: In neonates requiring resuscitation (P), can the intraosseous route (I), rather than the intravenous route (C), provide intravascular access for administration of emergency medications and fluids (O)?

Is this question addressing an intervention/therapy, prognosis or diagnosis? Intervention: intraosseous access in neonates

State if this is a proposed new topic or revision of existing worksheet: Revision

Conflict of interest specific to this question
Do any of the authors listed above have conflict of interest disclosures relevant to this worksheet? No

Search strategy (including electronic databases searched).

Electronic databases and bibliographies of journal articles were reviewed for references specific to neonatal application of intraosseous infusions. MeSH terms included infusions/intraosseous. Key words included neonate, pediatric, intraosseous, vascular access, resuscitation, survival, and outcome.

Data Bases: Medline, Cochrane Data Base of Systemic Reviews, Embase, and Cumulative Index to Nursing and Allied Health Literature were reviewed.

• State inclusion and exclusion criteria

Inclusion criteria for review included intraosseous infusions in neonates, infants and children. The data base searches for key terms included human and animal studies that pertained to resuscitation and vascular access. The search using MeSH terms was limited to humans and neonates or young infants through 24 months of age. Information about neonates and infants younger than 3 months of age was gleaned from the data base searches. Pharmacologic data was anecdotal in human studies so select animal studies regarding drug distribution during intraosseous infusion were reviewed. Bibliographies of manuscripts specific to neonates and infants were also searched for additional references.

OVID (neonate and intraosseous).mp. [mp=ti, ot, ab, nm, hw, kw, tx, sh, ct] 5

OVID (newborn and intraosseous).mp. [mp=ti, ot, ab, nm, hw, kw, tx, sh, ct] 94

OVID intraosseous resuscitation.mp. [mp=ti, ot, ab, nm, hw, kw, tx, sh, ct] 3

SearchDatabase name: PubMed forSearch term: neonate and intraosseous(82)
Bibliography documents searched: 219+ some not quantitated during C2005 review

Total: 799+

Exclusion criteria included references that did not pertain to intraosseous access and case studies and series that excluded young infants.

Twenty-two primary references and six review references are cited because they pertain specifically to neonates or infants less than 3 months of age. Few new primary references, other than review references, have been published since the previous worksheet. Titles of 799 citations were scanned.
# Summary of evidence

## Evidence Supporting Clinical Question

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<td>Martino Alba (A,C)</td>
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**Level of evidence**

- **A** = Return of spontaneous circulation
- **B** = Survival of event
- **C** = Survival to hospital discharge
- **D** = Intact neurological survival
- **E** = Other endpoint

*Italics = Animal studies*
**Evidence Neutral to Clinical question**

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A = Return of spontaneous circulation  
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**Evidence Opposing Clinical Question**

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*Italicics = Animal studies*
Reviewer’s Final Comments:

The intraosseous route for temporary vascular access during emergency resuscitation is infrequently reported in neonates requiring resuscitation. (DeBoer, Engle, Glaeser, Heinild, Rosetti, Seigler, Spivey, Tocantins) Approximately 82 newborns resuscitated or stabilized using intraosseous (IO) vascular access are documented in the literature; 29 of these received IO infusions within hours of birth. (Ellemunter, Friedman, Ghirga, Heinild, Kelsall, Lake, Martino, Nasimi, Ramet, Singh Tomar) Several publications about IO access include an undocumented number of infants with ages up to 28 days who were resuscitated after the birth hospitalization. (Claudet, Glaeser, Heinild, Seigler, Tocantins) Fluids and medications reported to have been successfully administered to neonates through IO access include epinephrine, atropine, sodium bicarbonate, adenosine, catecholamines, volume expanders, calcium gluconate, analgesics, sedatives, muscle relaxants, glucose, blood products, and antibiotics. (Buck, deCaen, Ellemunter, Heinild, Rosetti, Spivey, Tocantins) Thus, the intraosseous route for intravascular medication and fluid administration in neonates is feasible. No studies comparing intravenous and IO access for infusion of fluids and medications for any clinical outcome in neonates (such as survival, return of spontaneous circulation, and developmental status) have been published. Few studies have reported complications of IO infusions or access (infection, fracture, infiltration, leakage compartment syndrome, dislocation, fat embolism) in neonates only. (Heinild, Moller, Seigler, Stoll, La Flesch, Ellemunter, Engle, Buck, DeBoer, Spivey, Rosetti)

The skill for establishing IO access is simple and sustained by clinicians, such as emergency transport technicians and staff, despite the low frequency of the procedure. (Abe, Banerjee, Fiorito, Glaeser, Miner, Moller) The procedure is also more quickly learned and performed than umbilical vein catheter placement by clinicians unfamiliar with the technique. Use of IO access in neonates and young infants pertains most to the out-of-hospital setting or outside of the delivery room/neonatal intensive care unit, although there may be rare instances when rescue IO access may be beneficial for patients in such locations. (DeBoer, Engle, Fiorito, Miner, Moller)

The small number of neonates reported to have received IO medications and fluids for resuscitation supports the notion that IO access to rescue newborn infants requiring resuscitation is infrequently needed. (DeBoer, Engle, Fiorito, Heinild, Miner, Moller, Rosetti, Spivey, Tocantins) It could be speculated that the availability of rapidly accessible umbilical vessels is the most likely reason for absence of need for IO access. Umbilical or peripheral routes for vascular access in neonates in the delivery room may also be preferable, despite the additional time that may be required, because successful intravascular cannulation may avoid the additional vascular access procedures required after resuscitation with IO access.

The evidence to support rescue use of the IO route in neonates being resuscitated is level 4 or 5. It is unlikely that substantial new information will become available because large randomized trials or case-controlled studies (levels 1 to 3) will not likely be performed because of the low incidence of resuscitations requiring intravascular medications and the presence of providers skilled in establishing other routes of vascular access in many hospital settings.

Summary statements from Review of the Literature of IO Access for Resuscitation and Stabilization of Critically Ill Patients (Neonates, Children, Adults, Animals):

1. Rescue and Primary IO access are rarely required in neonates requiring resuscitation. (Claudet, DeBoer, Fiorito, Miner, Moller, Tocantins)
2. Rescue IO access (versus primary IO access before IV access attempts have been unsuccessful) is rapid, safe, and effective, especially when performed by experienced personnel. (Abe, Banerjee, Buck, Claudet, Ellemunter, Engle, Fiorito, Fiser, Miner, Moller, Seigler, Spivey)
a. Although IO placement and use in newborns is easily learned, insertion of an IO needle may be more difficult when performed by caregivers with limited experience and competence with placement, stabilization of the needle, and infusion.

3. Rescue IO access is preferred over primary IO access because of difficulty stabilizing IO cannula, large size of available IO needles (butterfly needle used in one 800 gram infant, Lake and Emmerson) and requirement for additional intravascular cannulation procedures following resuscitation.

4. Primary IO access is acceptable when equipment or personnel skilled in establishing venous access are not available or when other vascular access is unlikely to be secured (absent cardiac output states). (Buck, DeCaen, DeBoer, Engle, Fiorito, Minor, Moller, Spivey)

5. Most medications and fluids can be given via the intraosseous route. (Buck, Ellemunter, Tocantins) There are several special circumstances to consider:
   a. Viscous fluids will need manual pressure or an infusion pump.
   b. Saline bolus following medication administration facilitates delivery into the central vasculature.
   c. Therapeutic concentrations of cefotaxime, amikacin, ampicillin, and gentamicin are achievable but generally lower than when usual intravenous doses are administered. Therapeutic concentrations of vancomycin, tobramycin, ceftriaxone, and chloramphenical are not achieved when usual intravenous doses are given through the intraosseous route.
   d. Therapeutic concentrations of phenobarbital, but not phenytoin, are achievable.

6. Complications are infrequent (< 1%) but may include osteomyelitis (0.6%), fracture, compartment syndrome, skin necrosis, subcutaneous abscess, fat or bone marrow emboli, and short-term periostitis (no long-term effects on bone growth reported). (Engle, Fiorito, Fiser, Heinild, La Fleche, Moller, Stoll, Tocantins)

7. Contraindications may include osteogenesis imperfecta, other metabolic bone disease, fracture, previous puncture through the bone, cellulitis or burn at the proposed insertion site, vascular insufficiency in the limb. (Buck,)

8. Laboratory studies from the bone marrow are interpreted as mixed venous samples. pH and other measures of acid-base balance are unreliable after sodium bicarbonate administration.

Acknowledgements:

Citation List


Note: LOE 5. Poor quality. Supportive of IO access. Randomized trial comparing the ease of learning intraosseous versus umbilical venous access in model systems by medical students. Intraosseous access was more quickly and easily learned.


Note: LOE 5. Poor quality. Supportive of IO access. Randomized (alternate patient selection), unblinded comparative trial of IO versus IV access in children 3 - 24 months of age with severe dehydration. IO access was rapid, safe, effective, and more easily placed than IV access in 3-24 month old children.

Note: LOE 5. Poor quality. Support and Opposition to IO access. Systematic review of the literature on the infusion technique and pharmacology of drug administration through IO access devices.


Note: LOE 5. Poor quality. Supportive of IO access. Intraosseous infusion in the prehospital setting for resuscitation of children 2 weeks to 9 years of age is effective, rapid, and safe.


Note: LOE 5. Poor quality. Support and Opposition to IO access. Review article on intraosseous access in critically ill patients, including children.


Note: LOE 5. Poor quality. Support and Opposition to IO access. Review article on IO infusion in neonates, with a focus on neonates outside the immediate newborn period (birth hospitalization).


Note: LOE 4. Poor quality. Supportive of IO access. Largest case series of intraosseous access for resuscitation and stabilization of sick newborn infants at or immediately after birth. Intraosseous access was found to be rapid, safe, and effective.


Note: LOE 5. Poor quality. Support and Opposition to IO access. Review article focused on intraosseous access in preterm and term neonates. Because literature on this topic is limited, conclusions have been determined from experience in children and adults and general principles.


Note: LOE 5. Poor quality. Supportive of IO access. Safety and efficacy of prehospital intraosseous access in children 3 weeks to 14 years of age is described in this case series of 47 patients. Complications (local edema and infiltration only) occurred in 12% of cases.

Note: LOE 5. Poor quality. Supportive of IO access. No leg length discrepancy was found in 10 children who received intraosseous infusions.


Note: LOE 5. Poor quality. Supportive of IO access. Case study of an infant receiving intraosseous adenosine to treat supraventricular tachycardia.


Note: LOE 5. Poor quality. Supportive of IO access. Two cases of intraosseous infusions in preterm infants are described.


Note: LOE 4. Poor quality. Supportive of IO access. Large case series of 152 patients treated with intraosseous (IO) infusions, including young infants. Emergency medical technicians and paramedics maintained proficiency in IO placement and infusion despite infrequent use. Success in placement of IO devices was 85% in children less than 1 year of age.


Note: LOE 4. Poor quality. Supportive of IO access. Large case series of pediatric intraosseous infusions, including a few newborn infants.


Note: LOE 5. Poor quality. Supportive of IO access. Two cases of infants in the neonatal intensive care setting who were resuscitated with intraosseous access are reported.


Note: LOE 5. Poor quality. Opposition to IO access. Case report of tibial fractures in a 3 month old infant following attempts to establish IO access.


Note: LOE 5. Poor quality. Supportive of IO access. Case presentation of intraosseous access for fluids and medications in a preterm infant.

Note: LOE 5. Poor quality. Supportive of IO access. A case of intraosseous access in a neonate is reported in a letter to the editor.


Note: LOE 5. Poor quality. Supportive of IO access. Case series of children less than 5 years old in cardiac arrest rescuscitated with intraosseous access placed in the prehospital setting by paramedics.


Note: LOE 5. Poor quality. Supportive of IO access. Case series (18 children) resuscitated with intraosseous access. Intraosseous needle placement was rapid, successful and associated with few complications.


Note: LOE 5. Poor quality. Supportive of IO access. Single case of a 34 weeks' gestation infant with septic shock stabilized with intraosseous infusion of fluids and medications.


Note: Case LOE 5. Poor quality. Supportive of IO access. Report of an 800 gram infant treated with intraosseous access for fluid and medications.


Note: LOE 5. Poor quality. Support and Opposition to IO access. Review article about tibial intraosseous infusion as an alternative intravenous route in children less than 3 years old. Review of the literature indicates intraosseous access is a rapid, reliable method with an acceptably low complication rate.


Note: Case LOE 5. Poor quality. Supportive of IO access. Case series of prehospital pediatric patients resuscitated with intraosseous infusions. Intraosseous access was established quickly (< one minute) and complications were not significant.

Note: Case LOE 5. Poor quality. Supportive of IO access. Two neonatal cases of intraosseous infusion for resuscitation are presented. Intraosseous provided temporary vascular access for volume expansion and medication administration until intravenous access could be secured.


Note: LOE 5. Poor quality. Support and Opposition to IO access. Medical progress reviewing the history, physiology, technique and clinical indications for intraosseous infusions in critically ill infants and children.


Note: LOE 5. Poor quality. Opposition to IO access. Complications of intraosseous infusion of high doses of adrenaline in a 3 month old infant are reported.


Note: Case LOE 5. Poor quality. Supportive of IO access. One neonate (8 days old) and one infant (7 weeks old) treated with intraosseous infusions are reported in this case series of 40 patients, mostly adults.