Prehospital Use of Semiautomatic IO in the Pediatric Population
A Critically Appraised Topic

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Clinical Scenario
A 10 week old baby is found in cardiac arrest for unknown amount of time. EHS was called and the baby received compressions and was intubated on scene. An IV was started as well. They arrived to the hospital 35 minutes after the call started despite only coming from downtown Halifax. Would this baby have benefitted from an IO?

Question
Will the addition of an EZ-IO gun in ambulances result in increased frequency of IO use in pediatric patients and will it affect patient outcomes?

PICO
Population: Pediatric patients in the prehospital setting
Intervention: Intraosseous access for medication or fluids
Comparison: Semiautomatic/powered IO versus manual IO and intravenous access
Outcome: Efficiency of vascular access and frequency of IO use if semiautomatic available, patient outcomes

Search Strategy
The database used was PubMed. The search was kept broad in order to maximize the number of results. An advanced search was done using "intraosseous" [title/abstract] AND "pediatric" [title/abstract] as search terms. This resulted in 163 articles. Of those 163, only 43 articles had pediatric and intraosseous as a topic in the title and/or abstract. A significant number (15) were published between 1985 and 1995. The 163 articles were individually reviewed (by abstracts) to ensure they included the terms such as "prehospital," "out-of-hospital," "EMT," "paramedic," pediatric" and "intraosseous" in the title or abstract. That resulted in 19 articles to review more closely. The 19 articles titles are below (reasons for not including in the CAT are in brackets). Finally, an article by Olaussen, et al. entitled "Intraosseous access in the prehospital setting: Literature review," was reviewed to ensure that no articles were missed in the search. Only two of the most appropriate articles were reviewed in detail.

Relevant Papers = 2

Myers LA, Russi CS & Arteaga GM. Semiautomatic intraosseous devices in pediatric prehospital care. Prehospital Emergency Care (2011);15(4): 473-476.

This article is a retrospective chart review that looked at data regarding intraosseous (IO) insertion rates in children less than 18 years of age in the pre-hospital setting (12-site,

statewide ambulance service). The paramedic crews carried manual IO's from January 2003 to February 2007 and semiautomatic IO's (EZ-IO) from March 2007 to May 2009.

The population consisted of all children <18 years of age in whom paramedics attempted to place an IO. The intervention was the placement of an IO, either manually or with a semiautomatic device. They looked at rates of IO placements (both manual and semiautomatic), success rates/number of attempts and IV attempts prior to IO insertion.

Overall, there were 31 manual and 60 semiautomatic IO insertions. Interestingly, the time interval for the manual group was 50 months as compared to only 26 months for the semiautomatic device. There was basically double the use of IO's in half the time interval.

The first-attempt success rate was no different between the 2 groups. The first-attempt success rate in the manual group was 80.6% (25/31) and in the semiautomatic group was 83.9% (52/62) ($p = 0.98$) (denominator is 62 instead of 60 because 2 patients had 2 IO's placed). The number of IO insertion attempts was no different between the groups. In the manual group, there were 37 attempts for 25 successful insertions (67.6% success) and in the semiautomatic group, there were 72 attempts for 58 successful insertions (80.6% success) ($p = 0.52$). With regards to the number of IV attempts before IO insertion, there were significantly less IV attempts in the semiautomatic group. In the manual group, 35.5% of patients (11/31) had IV attempts and in the semiautomatic group, only 1.7% of patients (1/60) had IV attempts ($p < 0.001$). The most important part is that in pulseless or apneic children, in the manual group 26.9% (7/26) had IV access attempted prior to IO whereas in the semiautomatic group none had IV attempts. The paramedics went directly to IO.

Interestingly, the first-attempt success and the overall number of attempts was no different between the 2 groups. This has to be interpreted with caution as it might be due to the small numbers in the study. The part that reinforces the importance of the semiautomatic devices is the decreased frequency of IV attempts. This is could be lifesaving in an arrest situation. Furthermore, second and third attempt were never successful in the manual group but 66.6% were successful in the semiautomatic group which lends support to semiautomatic IO use.

It is well known that a retrospective chart review has its limitations. In the pre-hospital setting, it is difficult to document accurately, especially number of IV or IO attempts. Additionally, did the increase in IO use in the second half of the study simply result from the fact that there was a novel tool in the tool box or because of increased teaching/publicity about IO's for the paramedics? The article suggests that it may be secondary to increased confidence in IO use by paramedics. It may have been more beneficial to look at the semiautomatic IO a year or more after the introduction of the new tool. One must also remember that this study has a small sample size but the population was similar between each IO group. Furthermore, the population in this study is representative of our pediatric population in prehospital care. The paper did not comment of the paramedic level of training and experience although it would have been

complicated given the retrospective nature of the study. There was no mention of patient outcomes or complications in this study which is an important aspect in the introduction of a new intervention/tool.

Based exclusively on this small study, I would not promote the use of the EZ-IO even though the results are very encouraging. The fact that paramedics were more willing to use IO's in children is an important aspect of pediatric care. On the other hand, it would be important to know in a larger study whether the use of EZ-IO affects patient outcome. It would seem intuitive to extrapolate that if paramedics were more willing to use EZ-IO and less likely to try IV access in an arrest situation, that EZ-IO saves lives. They just need to get this data.

Frascone RJ, Jensen J, Wewerka SS & Salzman JG. Use of the pediatric EZ-IO needle by emergency medical services providers. Pediatric Emergency Care (2009);25(5): 329-332.

This study is a prospective pilot study conducted between May 2006 and October 2007. There were 14 EMS agencies involved in the study (urban to rural, full-time to volunteer). The participants were paramedics and nurses and all were trained to use the EZ-IO. They collected data on insertion rates, comfort with EZ-IO use, ease of fluid flow, and complications by a telephone interview with the EMS provider after the IO attempt.

The population consisted of all children, although they did not specify an age (patients in demographics table ranged from 3-180 months). The inclusion and exclusion criteria were clear. The inclusion criteria were (1) estimated patient weight between 3 and 39 kg, (2) anticipated difficult intravenous (IV) access and/or 1 to 2 failed IV attempts, and (3) immediate use of the device for pediatric patients experiencing cardiac arrest. Exclusion criteria were (1) recent tibia or femur fracture, (2) recent IO attempt at the same site, (3) apparent infection over the insertion site, or (4) inability to identify insertion site landmarks. The intervention was the placement of an IO using EZ-IO. Unfortunately, there was no comparison group.

There were 19 IO insertions during the study and all placed by paramedics. There was a 95% (18/19) success rate. The one failure was due to an inability to infuse fluids. An estimate of time to successful insertion which was <60 seconds in 71% (12/17). Only 37% (7/19) had an IV attempted before the IO.

82% (14/17) felt the device worked very well and 61% (10/17) felt very comfortable using the EZ-IO. There were 5 complications (2 infiltrations, 2 slow flow rates, 1 dislodgement).

There were a total of 19 patients, 16 medical and 3 trauma. 10/16 (62%) medical patients had cardiac arrest and 6/16 (38%) had a seizure. Four patients (21%) were pronounced dead ED, and 1 patient (8%) achieved a ROSC in ED. The outcome for the remaining 14 patients (74%) is unknown.

Unfortunately, there were 2 non-responders to the evaluation questions which may have a significant impact on such a small pilot study. Additionally, the estimate of time to insertion is a weak point as time should have been monitored if it was going to be evaluated and commented on in the study. Initially, nurses and paramedics were trained in the use of the EZ-IO although only paramedics inserted all IO's in this study. A future study should focus exclusively on paramedics in prehospital care. The study does not specifically comment on whether multiple attempts were required in any case. A significant weakness is that all replacement needles during the study were donated by Vidacare Corporation, the creators of EZ-IO. Lastly, the authors did not review ED/hospital records to get a complete data set for complications and outcomes. 74% of outcomes are missing.

Based on this study, I would not be able to recommend the use of EZ-IO in the prehospital management of pediatric patients. The study was too small and a focus was on comfort and ease of EZ-IO use rather than focusing on measurable parameters such as time to insertion and specific outcomes. Paramedic comfort and ease of use of the IO is important to ensure that IO's are used in children but if EZ-IO doesn't change patient outcomes compared to manual IO, I would have trouble encouraging it's use. Unfortunately, the outcome data was very incomplete and not a focus of this study.

Conclusion

The literature regarding the use of IO's in prehospital care increased dramatically in the mid 1980's and early 1990's and since then, there have not been many quality pediatric prehospital studies. My focus was to compare manual versus semiautomatic IO's (EZ-IO) to understand if the EZ-IO will result in an increased frequency of IO use in pediatric patients and whether EZ-IO affects patient outcomes. Myers, et al showed clearly that the EZ-IO in their study increased the frequency of IO insertions during the study period. This is encouraging. Frascone, et al may have found a possible reason for Myers et al's increased IO use. Frascone, et al showed that paramedics expressed that the EZ-IO worked well and paramedics were comfortable using the EZ-IO. There was insufficient evidence to prove that EZ-IO changes patient outcomes as I could not find a study that compared patient outcomes in manual IO versus EZ-IO patients. A great study would include a larger population comparing manual and semiautomatic IO insertions in a randomized fashion and have follow-up on patient diagnosis and outcomes. Overall, there is insufficient evidence to support the use of EZ-IO but there is also no evidence to say they don't work. If they increase compliance with guidelines for prompt vascular access in critical situations, EZ-IO is a great tool.

Relevant Papers:

AUTHOR, DATE	POPULATION: SAMPLE CHARACTERISTICS	DESIGN (LOE)	OUTCOMES	RESULTS	STRENGTHS/ WEAKNESSES
Myers LA, Russi CS, Arteaga GM Oct/Dec 2011	Children <18yrs who had an IO attempted in pre-hospital between 2003-2009 Similar characteristics	Retrospective chart review Jan 2003-Feb 2007 manual IO Mar 2007-May 2009 EZ-IO	Frequency of IO use (manual and EZ-IO) Success rates Primary clinical impressions Treatment after IO insertion	**Frequency** 31 M and 60 S **First attempt success** M 25/31 (80.6%) S 52/62 (83.9%) – 2 had 2 IO's **Multiple attempts** Never successful in M 6 66.6% success for S (6 multiple and 4 no success) **Overall success** M 37 tries for 25 (67.6%) S 72 tries for 58 (80.6%) p=0.52 **Clinical status** Pulseless/apneic M83.9%/S70% Sz M9.7%/S16.7% Resp M3.2%/S3.3% Trauma 3.2%/S1.7% **Treatment** M 21/25 (84%) S 41/56 (73.2%) **IV dropped 3-fold** M 11/31 (35.5%) had IV try S 1/60 (1.7%) p<0.001) in arrest	Retrospective chart review misses pts and looks back Accuracy of number of attempt Small numbers Studying when EZ-IO was new possibly made use go up No comment on outcomes No comment of level of EMS training Appropriate pt population Good review on numbers of IV and IO Good to include diagnoses
Frascone RJ, Jensen J, Wewerka SS, Salzman JG May 2009	Pre-hospital children (?Age – pt demographics 3-180 m). Inclusion - estimated patient weight between 3 and 39 kg; anticipated difficult IV access and/or 1 to 2 failed IV attempts; immediate use cardiac arrest. Exclusion - recent tibia/femur #; recent IO attempt at same site; apparent infection at site; inability to identify landmarks.	Prospective pilot study May 2006 to Oct 2007 EMT's and nurses	Insertion rates Comfort with EZ-IO Ease of fluid flow Complications (phone interview)	**Rates** 19 IO all by paramedics **Success** 95% (18/19) success rate. 1 failure d/t inability to infuse. **Comfort** 82% (14/17) felt IO worked very well and 61% (10/17) felt very comfortable **Complications** 5 (2 infiltrations, 2 slow flow rates, 1 dislodgement). **Cause** 19=16 med and 3 trauma 10/16 (62%) medical patients had cardiac arrest and 6/16 (38%) had a seizure. 4 (21%) pronounced dead ED, and 1 (8%) ROSC in ED. **Outcome** of 14 patients (74%) unknown. **Estimate of time** to successful insertion which was <60 seconds in 71% (12/17) 37% (7/19) had an IV attempted before IO	Small pilot study No comparison group Included nurses 2 non-responders out of 19 is a lot estimation of time to insertion Replacement needles donated by VidaCare No comment on multiple attempts Did not review ED/hospital records to get complications and outcomes. 74% of outcomes missing. Good to ask comfort Good inclusion and exclusion criteria

Results = 19

1. Intraosseous access in the prehospital setting: literature review. Prehospital Disaster Medicine 2012 – literature review only

2. Intraosseous line use, complications, and outcomes among a population-based cohort of children presenting to California hospitals – Pediatr Emerg Care 2011 – ED IO only

3. *Semiautomatic intraosseous devices in pediatric prehospital care – Prehosp Emerg Care 2011*

4. IO infusion in the pediatric emergency medical service. Analysis of emergency medical missions 1990-2009 – Anaesthesist 2011 - German

5. Intraosseous devices: A randomized controlled trial comparing three intraosseous devices – Prehosp Emerg Care 2010 – nurses on helicopter EMS and adult and pediatric

6. *Use of the pediatric EZ-IO needle by emergency medical services providers – Pediatr Emerg Care 2009*

7. Powered intraosseous insertion provides safe and effective vascular access for pediatric emergency patients – Pediatr Emerg Care 2008 – looked at ED physicians, PICU, and EMS

8. The role of intraosseous vascular access in the out-of-hospital environment – Prehosp Emerg Care 2007 – resource document, adult and pediatric

9. Intraosseous access in the setting of pediatric critical care transport – Pediatr Crit Care Med 2005 – critical care transport teams transporting to PICU

10. Take aim – hit your target. A comprehensive approach to pediatric intraosseous infusion, including site selection, needle insertion & ongoing assessment: Part 2 – JEMS 2000 – more a teaching document

11. Comparison of two intraosseous infusion techniques in an EMT program – Acad Emerg Med 2000 – mannequin study

12. Intraosseous infusion performed in the prehospital setting: South Carolina's six-year experience – J S C Med Assoc 1997 – looked at outcomes in pediatric cardiac arrest only, no focus on power IO

13. Intraosseous device of perfusion. Apropos of three cases before hospitalization – Cah Anesthesiol 1996 – small case report in French

14. Improved prehospital pediatric ALS care after an EMT-paramedical clinical training course – Am J Emerg Med 1994 – not a focus in IO's

15. Intraosseous infusion in pediatric patients – J Am Osteopath Assoc 1994 – not a study, more a description in an odd journal

16. Adoption of intraosseous infusion technique for prehospital pediatric emergency care – Pediatr Emerg Care 1990 – old paper using a telephone interview to EMS agencies to see use of IO

17. Prehospital intraosseous infusion by emergency medical services personnel: a prospective study – Pediatrics 1989 –old, small study on manual IO in arrest

18. Prehospital use of intraosseous infusion by paramedics – Pediatr Emerg Care 1989 – old, small study in children <5yrs in arrest with manual IO

19. Intraosseous infusions by prehospital personnel in critically ill pediatric patients – Ann Emerg Med 1988 – old, small study on manual IO in ground and flight EMS