

## Powered Intraosseous Device (EZ-IO) for Critically Ill Patients

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We reviewed the charts of 25 patients who underwent powered intraosseous line insertion between July 1, 2008 and August 31, 2010 to determine its users, indications, procedural details, success rates, and complications. Intraosseous (IO) line was inserted in the anteromedial aspect of the proximal tibia in all patients. The first attempt was successful in 80%, and the median duration for insertion of the IO line was 4 hours. Extravasation was the most common complication. Ninety-six percent of the physicians had undergone prior training in IO insertion. Because of its high success and short procedure time, IO access should be the first alternative to failed vascular access in critically ill children. Training in IO should be extended to all who care for pediatric patients in inpatient as well as in prehospital and emergency department settings.

**Key words:** Children; Intraosseous; Pediatric emergency; Powered intraosseous device.

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Due to ease of insertion and minimal complications, peripheral intravenous (IV) catheterization is usually attempted first for infusion of fluids and medications. Intraosseous (IO) needle placement is one of the foremost suggested alternative routes for obtaining venous access after failure to gain peripheral vascular access for IV infusions. Alternative venous access techniques for critically ill young children can be time-consuming and are less likely to be successful than IO intervention [1-3].

Several different commercially available IO cannulation devices are available. Manual IO needles, battery powered driver (EZ-IO) and impact-driven devices (Bone injection gun [BIG], FAST) are preferred for IO cannulation [4]. The device EZ-IO was approved by Food and Drug Administration in 2004 [4] and has recently been used in prehospital setting [10]. This device uses the same physiological concept for fluid and medications delivery. The device consists of battery-powered driver for insertion with different needle length and gauge for placement in children and adults [5].

Little data exist in the literature concerning the spectrum of PED patients who undergo EZ-IO access. Most studies on IO access concern prehospital insertions or the acquisition of skills needed to perform the procedure [6-8]. The present study aimed to present the experience of EZ-IO insertions in the pediatric emergency department.

### METHODS

The study protocol was approved by our University Ethics Committee. Charts of consecutive children who underwent an attempt at IO placement in our emergency department from July 1, 2008 to August 31, 2010 were reviewed. Demographic and basic clinical data were recorded. Duration of IO use and complications were also recorded. Prior experiences of the physician regarding IO placement was obtained by questionnaire.

During the study period, IO insertion with the EZ-IO was routinely attempted if the first attempt at peripheral IV placement was unsuccessful within 60 seconds. A successful IO access was defined as the ability to aspirate bone marrow or infuse saline without palpable extravasation.

### RESULTS

During the study period, 25 intraosseous insertions were performed from 61188 patients. Their median age was 18 months [range: 6-204 months; IQR (25-75): 10-36 months]; 76% were male. Twenty-one (84%) of the cases were  $\leq$  6 years old and 20 (95.2%) of those were  $\leq$  3 years old.

The characteristics of the 25 patients undergoing IO access are shown in **Web Table I**. The IO was used in 12 previously healthy children and in 13 who had a chronic disease. Left, right, and bilateral proximal tibias were used in nine (36%), seven (28%), and nine (36%) of

cases, respectively. Success rate at first attempt was 80%. Presenting complaints of the children were respiratory distress/failure in six (48%) patients, circulatory disorder in twelve (24%) patients. Seven patients presented in cardiopulmonary arrest.

The duration of time needed to insert the IO cannulation was not recorded. The IO line was in place for a median time of 240 minutes [range: 10-1440 minutes; IQR (25-75): 75-720 minutes]. The IO line was used for over 4 hours in 11 (44%) of cases and for 24 hours in three (12%) cases. Use of the IO was discontinued because of a complication in four patients: extravasation occurred in three and the IO needle was dislodged during transport in one. No serious complications were observed. IO needles were removed in 24% because peripheral venous access was eventually obtained; other patients went to the ICU with the IO line in place. Five (20%) of patients died in emergency department, 12 (48%) in PICU and two (8%) in pediatric surgical ICU.

The mean experience of residency training of the pediatrics residents who placed the IO lines was  $41.3 \pm 15.7$  months (median 36 months; min-max: 30-108 months). 76% of the physicians had performed IO insertion on patients before the study began: (74% for treatment, 5% for diagnostic purposes (*e.g.* bone marrow aspiration), and 21% for both diagnostic and therapeutic purposes); and 96% had received training on IO insertion (64% during residency in-service training, 36% in an Advanced Pediatric Life Support course (one physician was also an APLS course instructor)). 81.8% of all physicians had placed an IO line in a patient before the study was initiated.

## DISCUSSION

The success rate of intra-osseous application at initial attempt in this study was 80%, which is in parallel with the rates of previous reports (70-95%) [9,10]. The major two factors led to increased success rate in our applications were those, majority of our residents underwent IO line training (96%) and most of them had an experience on IO application and already placed an IO line in a patient prior to this study (81.8%). The main distinction of our report from others is the documented experience of our physicians about IO application.

Regarding guideline recommendations, intraosseous line should be used for a maximum duration of 3-4 hours and afterwards should be replaced with a venous line as soon as possible [11]. Similarly, median duration of IO line use in our study was 4 hours. The most common complication of IO application is extravasation reported

with a rate of 12% in our study and alike previous reports [12]. Severe complications (*i.e.*: compartment syndrome) due to IO line were rarely reported [13].

In United States, the EZ-IO has been approved for use at two anatomical sites; proximal tibia and humeral head [4]. However the most favorable site is proximal tibia with a reported rate of 88-95% in several studies [9,13]. Similarly, antero-medial side of the proximal tibia was used in all cases in this study due to its superficial cortex and proximity of the medullary cavity to the application area.

IO cannulation method is likely to be used under emergent conditions (*i.e.*: cardiopulmonary arrest) by emergency care providers owing to its high success rate and short procedure time. As an alternative to failed vascular access, ability of the emergency care provider to supply an IO line should be a must in order to secure the life of a patient in emergency care. Therefore, didactic and hands-on training for IO line insertion should be given to all physicians working at PED settings.

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