Comparison of 3 different intraosseous access devices for adult during resuscitation. Randomized crossover manikin study

Andrzej Kurowski, MD, PhD a, Dariusz Timler, MD, PhD b,⁎, Togay Evrin, MD c, Łukasz Szarpak, MSc d

A R T I C L E  I N F O

Article history:
Received 8 August 2014
Received in revised form 10 September 2014
Accepted 11 September 2014

A B S T R A C T

Background: The study was designed to investigate the success rate and time of insertion intraosseous access during simulated resuscitation.

Material and methods: This was a randomized crossover study involving 107 paramedics. They were timed from start of insertion attempt to successful insertion and asked to score perceived difficulty of intraosseous access devices. Bone injection gun (BIG) (WaisMed Company, Houston, TX), EZ-IO (Vidacare, Shavano Park, TX) and Jamshidi (Carefusion, San Diego, CA) were used in this study.

Results: Success rates for first intraosseous injection attempt were higher for the BIG (91.59%) than EZ-IO (82.66%) or Jamshidi (47.66%). Mean procedure time was 2.0 ± 0.7 vs 3.1 ± 0.9 minutes for EZ-IO vs 4.2 ± 1.0 minutes for Jamshidi.

Conclusions: The use of BIG is associated with excellent success rates for insertion and appears easier to use than EZ-IO or Jamshidi Intraosseous Needle. Further work to evaluate the use of the intraosseous access device in the emergency medical services is required.

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1. Introduction

Access to the bloodstream for the purpose of administering pharmacologic agents and conducting fluid therapy during life-threatening emergencies, such as resuscitation, is a priority in therapeutic procedures. Peripheral intravenous access remains an imperative standard, which for many years has not changed. However, cannulation of blood vessels during cardiac arrest, due to collapsed veins is a procedure that is most time consuming and difficult to implement.

In the immediate threat, to restore life, delay in time to access the circulatory system decreases the propensity of recovery in the situation of the victim and reduces the chances of survival. Cannulation of blood vessels, especially during resuscitation should be undertaken by experienced medical personnel.

The use of intramedullary injection site (intraosseous access) in a prehospital procedure is the most secure method of securing vascular access administration when intravascular peripheral vascular cannulation proves too difficult or is impossible to perform in children and in adults [1,2]. Traditionally, the indication for intramedullary access is to attempt peripheral vascular access in patients requiring urgent administration of medications, if within the first 2 minutes it is not possible to obtain intravenous access [3-5].

The aim of this study is to evaluate differences in the devices used to obtain successful intramedullary access using different intraosseous devices by paramedic personnel.

2. Materials and methods

This was a randomized crossover study involving 107 paramedics. All of them had completed training programs before using intraosseous devices comparable with certificated one. The study was approved by the Program Committee of International Institute of Rescue Research and Education. Detailed characteristics of the study group are presented in Table 1. The study was based on training using Stat Adult ALS Manikin with intraosseous Leg Trainer (Simulaids, Saugerties, NY), and the following devices were used: the bone injection gun (BIG) for adults, Waismed Company (Houston, TX); the Jamshidi Intraosseous Needle from Carefusion (San Diego, CA); and the EZ-IO Intraosseous Infusion System from Vidacare with needle 15 g × 25 mm (Shavano Park, TX). The study was voluntary and was conducted among persons participating in training.

The survey was voluntary and was conducted among persons participating in training, where cardiopulmonary resuscitation instruction is given by the International Institute of Rescue Research and Education (Warsaw, Poland). Study enrollment occurred from June 2013 to December 2013.
After the recruitment of volunteers for participation in this study, a 30-minute training on the technique involved in establishing intramedullary access on an adult patient during resuscitation was conducted, in accordance with the recommendations of the European Resuscitation Council [6]. Training involves a discussion and presentation on correct technique of obtaining intramedullary access using the standard BIG, Jamshidi Intraosseous Needle, and the EZ-IO device. After the training, the subjects were given 5 minutes of hands-on individual training on each method.

To determine the order in which to apply the different access devices within each group, a Research Randomizer program was used [7]. A group of 107 people participating in the study were divided by the program into 3 groups, one of which was to first make the assumption intramedullary access using BIG, the second using Jamshidi, and the third using the EZ-IO. After completing the procedure of creating intramedullary access, people had 20 minutes for a break and then performed another surgery procedure. The detailed procedure of randomization is presented in the Figure.

3. Results

During the study, 321 venous system access attempts were made; within these in 237 cases, the procedure was executed correctly using an intramedullary venous catheter (73.8%). The highest percentage of correctly executed punctures was with the BIG intraosseous device (91.59%), followed by EZ-IO (82.24%), and then Jamshidi Intraosseous Needle (47.66%; Table 2).

Statistically significant differences at the time of creating the intramedullary puncture are as follows: BIG vs Jamshidi (\( P = .007 \)) and BIG vs EZ-IO (\( P = .021 \)).

Table 3 shows the time of executions of intramedullary injection indicating the specific device. Intramedullary puncture during the 2 minutes was established with the following results: BIG (\( n = 83, 77.6\% \)), EZ-IO (\( n = 41, 38.3\% \)), and Jamshidi (\( n = 38, 35.5\% \)).

Table 4 shows the evaluation of people participating in the study and the ease of implementation devices during intramedullary injection using a variety of methods. The easiest method of access occurred using the BIG intraosseous device (1.83 points) followed by the EZ-IO (2.92 points) then the Jamshidi (4.68 points). There is a statistically

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**Figure.** Time to successfully perform the intraosseous access by each device.
significant difference in the assessment of BIG vs Jamshidi (P < .005), BIG vs EZ-IO (P = .021), and Jamshidi vs EZ-IO (P = .033).

3.1. Limitations

This study is limited by the small sample size and the simulation of venous access with manikins.

4. Discussion

Gaining access to the circulatory system in life-threatening conditions including arrest and cardiopulmonary resuscitation for administering pharmacologic agents is a key medical procedure that should be performed at the earliest possible stage. Often, because of the lack of pulse and thus the collapse of blood vessels, peripheral vascular catheterization may be difficult to perform. The acceptable alternative is to perform intraosseous access [8,9].

The technique of administering medications via intraosseous access dates back to the 1830s. The first description of intramedullary access was performed into the marrow cavity of man in 1834. Drinker et al [10], in 1922, studied the blood supply to the sternum and proposed to use it as a blood access site. Papper [11], in 1942, showed that the entire fluid flow through the network of blood vessels in the medullary cavity is virtually the same as the peripheral venous vessel. In 1989, Cameron et al [12] published a study presenting measurement techniques using radionuclides demonstrating empirically that the means of intraosseous fluid administration is just as fast as the intravenous method [3,13]. Accordingly, medication dosage is unchanged regardless of insertion location [14].

Currently, intraosseous access is a standard for emergency medicine in both children and adults [15]. This access method is recommended in the minutes proceeding European Resuscitation Council, Advanced Cardiovascular Life Support, or American Heart Association as an alternative means of access to the vascular system, specifically when it is not possible to gain access with an intravenous catheter or when too much time has lapsed with attempts [3]. Determination of the location and establishment of intramedullary puncture during practice is relatively easy to implement. The most common locations are the upper part of the medial tibia, sternum, or the upper part of the humerus. A less commonly assumed site is the medial surface of the ankle. Important contraindications are infectious skin at the injection site or presence of extremity site fracture. These are noted at the time of intramedullary access. Access during these conditions may result in systemic spread of infection or leakage into the surrounding space. In extremities, this may lead to compartment syndrome.

In practice, emergency medication is available via several devices in terms of performing intraosseous access. We studied 3 such devices: BIG, EZ-IO, and Jamshidi Needle. The BIG is a mechanical system that has a compressed spring, which will launch release of the needle. The expected insertion depth of the needle is controlled by the distal tip, either screwing or unscrewing it. It is possible to set the EZ-IO is that it remains semi-automat, including mechanical drive to use reusable drill bits, powered by a rechargeable battery. There are 3 types of needles used in this unit (15 g × 15 mm for children weighing 3–39 kg, 15 g × 25 mm for people with a muscular build, and 15 g × 45 mm for obese people). The Jamshidi Intraosseous Needle is a manual device. The depth of insertion is adjusted by screwing or unscrewing the tip. The needle progresses forward by rotation and the applied manual pressure. At the moment when the needle goes through the periosteum into the intramedullary space, there is loss of resistance.

Studies have shown during recorded clinical resuscitations that there is often prolonged intravascular access attempts and delay. Findings were confirmed by Rosetti et al [16] who pointed out that, in a group of 66 children with cardiac arrest, medical staff needed more than 10 minutes to gain access to a vein in 24% of cases and 6% did not manage to gain access. Several studies estimate that this scenario actually occurs in up to 10% to 40% of emergency situations [17–20]. Brunette and Fischer [21] demonstrated that the percentage of intramedullary access in children with cardiac arrest was higher (83%) than other forms of access: subclavian vein (77%) or percutaneous access (17%).

Implementing intramedullary injection in prehospital patients during resuscitation or shock is the most effective and safe method of administering medications intravenously. Research shows that medications given intramedullary achieve desired plasma concentrations in a time comparable with the medications given through a catheter placed in a central vein. In addition, it is distributed in a much shorter time than via intratracheal administration [22]. Intramedullary access also allows for blood analysis [6].

In this study, the highest percentage of successful first-time attempts with the use of the BIG device was 91.55% of the time, the EZ-IO percentage was 82.24%, and the Jamshidi Intramedullary Needle was 47.66%. Different results were obtained by Brenner et al [23], who studied comparative EZ-IO needles to BIG on human cadaver models. They showed that the injection site using the EZ-IO was characterized by higher rates of efficacy and were more user friendly during the procedure. Leidel et al [24] has demonstrated that the effectiveness of intramedullary puncture with BIG was 80%, and the EZ-IO was 90%; whereas, Sunde et al [25] found 55% and 96%, respectively. Gerritse et al [26] demonstrated an efficacy with BIG in children of 71% and adults 73%, and Levitan et al [27], when using the EZ-IO, established a percentage of successful first attempts of 96.9%; and Ong et al [28] reported 96%.

Gilman [29] in their study showed that there is no benefit in using BIG during applications nor any improved effectiveness of the treatment compared when it is compared with conventional tools. Hubble and Trigg [20] compared BIG when accessing the saphenous vein and noted that it took less time and was more successful. In our study, the entire procedure of creating access in the intramedullary from the time of opening the sealed container containing the device to the time access was achieved and varied in terms of duration for each device: BIG (2 ± 0.7 minutes), the EZ-IO (3.1 ± 0.9 minutes), and Jamshidi (4.2 ± 1.0 minutes).

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**Table 2**

<table>
<thead>
<tr>
<th>Device</th>
<th>Success rate on first attempt</th>
<th>Procedure time, min-max (min)</th>
<th>Procedure Mean (s)</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIG</td>
<td>98/107 (91.59%)</td>
<td>1.0-3.0</td>
<td>2.0</td>
<td>0.7</td>
</tr>
<tr>
<td>Jamshidi</td>
<td>51/107 (47.66%)</td>
<td>1.0-5.0</td>
<td>4.2</td>
<td>1.0</td>
</tr>
<tr>
<td>EZ-IO</td>
<td>88/107 (82.24%)</td>
<td>1.0-4.2</td>
<td>3.1</td>
<td>0.9</td>
</tr>
</tbody>
</table>

min-max, minimum-maximum.
When the respondents were interviewed, the paramedics stated that the easiest device for accessing was the BIG intramedullary injection device. The most difficult method to establish access proved to be the Jamshidi Intraosseous Needle. Calkins et al. [30] conducted research among soldiers and also showed that BIG was most often chosen as a first-aid tool (65%), consistent with our study’s results.

5. Conclusions

Regarding intraosseous access devices, we found rescuers’ choice of the easiest-to-use device to be the BIG. The BIG is associated with excellent success rates for insertion and appears easier to use than EZ-IO or Jamshidi Intraosseous Needle. Further work is needed to evaluate the use of the intraosseous access device in the emergency medical services field on human subjects.

References