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A comparison of two types of intraosseous vascular access systems during simulated cardiopulmonary resuscitation in pediatric patients

Porównanie dwóch typów wkłuć doszpikowych podczas symulowanej resuscytacji krążeniowo-oddechowej pacjenta pediatrycznego

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Abstract

Background. Obtaining intraosseous access is often the only alternative to intravenous access during cardiopulmonary resuscitation especially in emergency medicine. The aim of this study was to compare the efficacy of obtaining intraosseous access using the NIO-P versus EZ-IO in simulated cardiopulmonary resuscitation on pediatric patients. ***Material and methods.*** The study was designed as a prospective, randomized, cross-sectional simulated study. The study populations included 60 students in their last year of medical studies, which were divided into 3-person resuscitation teams. The evaluation included; time it took to obtain intraosseous access, correct localization of the intraosseous site often in the proximal tibia in pediatric patients, time it took to conduct the procedure and ease of implementation. ***Results.*** The median time to obtain intraosseous access using EX-IO was 23.5s [IQR: 18-32s] and NIO-P was 14.5s [IQR: 12-20s] (p = 0.014). Intraosseous access location accuracy was 75% with regards to EZ-IO and 100% for NIO-P. The ease of use for NIO-P was 2 points [IQR: 1-2.5] and for EZ-IO 3 points [IQR: 2-3.5] (p = 0.007). ***Conclusions.*** Obtaining intraosseous access by medical students in their final year using NIO-P when compared with EZ-IO was associated with a faster time to conduct the procedure, more accurate site location and easier execution for the procedure. *Anestezjologia i Ratownictwo 2018; 12: 18-23.*

Keywords: intraosseous access, cardiac arrest, efficiency, pediatric patient, rescue medicine

Streszczenie

Wstęp. Uzyskanie dostępu doszpikowego bywa niejednokrotnie jedyną alternatywą dla dostępu dożylnego podczas resuscytacji krążeniowo-oddechowej zwłaszcza w warunkach medycyny ratunkowej. Celem badania było porównanie skuteczności uzyskania dostępu doszpikowego z wykorzystaniem urządzeń doszpikowych NIO-P oraz EZ-IOP w warunkach symulowanej resuscytacji krążeniowo – oddechowej pacjenta pediatrycznego. ***Materiał i metody.*** Badanie zostało zaprojektowane jako prospektywne, randomizowane, krzyżowe badanie symulacyjne. W badaniu udział wzięło 60 studentów ostatniego roku studiów na kierunku lekarskim, którzy zostali podzieleni na 3-osobowe zespoły resuscytacyjne. Ocenie poddano czas uzyskania dostępu doszpikowego, poprawność zlokalizowania miejsca dostępu doszpikowego w części proksymalnej kości piszczelowej u pacjenta pediatrycznego, czas wykonania procedury oraz łatwość jej wykonania. ***Wyniki.*** Mediana czasu uzyskania dostępu doszpikowego z wykorzystaniem EZ-IO i NIO-P wynosiła odpowiednio: 23.5 [IQR; 18-32]s i 14.5 [IQR; 12-20]s (p = 0.014). Poprawność lokalizacji wkłucia doszpikowego w przypadku EZ-IO wynosiła 75% zaś w przypadku NIO-P – 100%. Łatwość uzyskania dostępu doszpikowego z wykorzystaniem NIO-P wynosiła 2 [IQR; 1-2.5] punktu, zaś w przypadku EZ-IO – 3 [IQR; 2-3.5] punktu (p = 0.007). ***Wnioski.*** W przeprowadzonym badaniu symulacyjnym, uzyskanie dostępu doszpikowego przez studentów ostatniego roku studiów lekarskich z wykorzystaniem wkłucia doszpikowego NIO-P w porównaniu z urządzeniem EZ-IO wiązało się z szybszym czasem wykonania procedury, bardziej poprawną lokalizacją wkłucia doszpikowego oraz łatwością wykonania samej procedury. *Anestezjologia i Ratownictwo 2018; 12: 18-23.*

Słowa kluczowe: wkłucie doszpikowe, zatrzymanie krążenia, efektywność, pacjent pediatryczny, medycyna ratunkowa

Introduction

Every cardiac arrest is a challenge for medical staff, which uses advanced techniques during resuscitation, with the end goal designed to save the patient's life. Cardiac arrest in a pediatric patient is a very difficult medical situation, and performing correct steps during resuscitation in this population, is a big challenge, as these situations rarely occur. Obtaining vascular access for drug delivery during resuscitation is difficult in adults, and even in children [1,2]. When working with a pediatric patient during life-threatening situation, time is of the essence when performing critical life--saving interventions.

Accessing the cardiovascular system is one of the most crucial steps in treating sudden cardiac arrest [3,4]. Acquiring early access in the pre-hospital setting is difficult, especially in the pediatric population. Obtaining intraosseous access (IO) is often the only alternative to intravenous access during cardiopulmonary resuscitation, especially in emergency medicine. Not being able to obtain intravenous access obliges us to find alternative ways of obtaining access, e.g. intraosseous access. Access to the bone marrow is recommended in children as it is in adults, in pre-hospital setting as well as in the emergency department. According to the recommendations from scientific societies such as: American Heart Association (AHA), American Academy of Pediatrics (AAP) and European Research Council (ERC), intraosseous injection is recommended from 2010 as an alternative for administering drugs and fluids [5,6]. Due to the fact that in recent years there has been an increase in the availability of mechanical IO devices, there use has risen accordingly. Today, we have various access sites for IO including: sternum, head of the humerus, proximal and distal tibia and radius [5-7]. Indications for inserting the IOP site are cardiac arrest or other life-threatening conditions in children. IO is a very effective access site for administering drugs and fluids. Intraosseous injection is achieved by direct insertion to the bone marrow using a specially designed device. The time it takes to insert the needle and come in contact with the bone marrow takes roughly 20-30 seconds. By properly inserting the injection, the flow can be up to 125 ml/min [7]. The recommended insertion place for IO injection in children is the proximal part of the tibia (1-2cm medially and around 1cm down from the tibial tuberosity to the flat portion of the bone).

The disadvantage of using IO injection is the high price of the kits and needles. IO is considered as a safe and effective method for obtaining access to

vasculature and the complications are relatively rare. The choice and decision to use a particular device depends on the protocol at the location, the availability of the devices [7], and the skills and knowledge of the equipment by the medical staff. Contraindications for IO access are fractures or other injuries at the site of a planned injection, as well as signs of infection in the area [8]. There is always a risk of complications with the placement of every injection. These complications may include: hematoma, inflammation and bone fractures. With the help of IO access, you can obtain material from the bone marrow and identify blood group, as well as analyze blood gases (the gases can be compared to that of central venous blood gases, provided that medications were not administered to the bone marrow before) [9]. The IO access should be maintained until stable conditions have been achieved. Optimally, it should be removed within 24 hours [10,11].

The aim of the study conducted by the authors was to compare the efficacy of two IO injection systems: NIO-P and EZ-IO in pediatric cardiopulmonary resuscitation simulations.

Material and methods

The study was a prospective, randomized, cross-sectional simulation. The study populations included 60 students in their last year of medical studies from May-June 2016. All participants in the study took part in practical and theoretical classes in the field of emergency medicine, where they learned how to perform pediatric CPR using the AHA guidelines [11]. PALS (Pediatric Advanced Life Support) training was conducted by AHA certified lecturers. During the course, students were taught the principles of resuscitation with or without defibrillation. In additional, the training included IO access in pediatric cardiac arrest simulations. During the training, two injection systems were used:

a) The Intraosseous drill ARROW® EZ-IO® (EZ-IO; Teleflex Medical Research Triangle Park, NC, USA) with an integrated driller stylet-tipped 15-gauge needle.
b) The New Intraosseous Pediatric Device (NIO-P; New Intraosseous PerSys Medical, Houston, TX, USA) – semi-automatic injection, which has a stabilizer that adds precision when finding the point of injection in the tibia of a child (figure 1).

After theoretical lessons and instructions on the technique for performing IO injection using these two methods, the study participants voluntarily participated in a study that was based on a scenario of a pediatric cardiac arrest patient in asystole. The participants were divided into three-person teams, where one person was in charge of airway management, the second person is assigned to perform effective chest compressions, while the third person is in charge of the defibrillator and obtaining intravenous access to administer drugs. Each team member took part in two cardiac arrest scenarios. The order of which method was chosen for intraosseous access was random using Research Randomizer. A detailed procedure for randomization is shown in figure 2.

During the study, it was made impossible to obtain intravenous access, making it necessary to gain intraosseous access. The time to obtain the access was analyzed as the time interval between grasping the intraosseous device out of the original packaging until completion of intraosseous needle placement. Additionally, the accuracy of locating the proximal part of the tibia was analyzed. After completing the procedure, all participants were asked to rate the ease of use for both devices on a scale of 1-10 (1 very easy, 10 very difficult).

All statistical analysis was performed using Statistica 13.2 EN (StatSoft, Tulusa, OK, USA). Results were presented as absolute values (percentages) or medians (interquartile ranges, IQRs). The two-sided Wilcoxon single rank test allowed to compare the procedure time. Subjective analysis for ease of performing the procedures was analyzed using Stuart-Maxwell test.

Figure 1. NIO-P Intraosseous access device

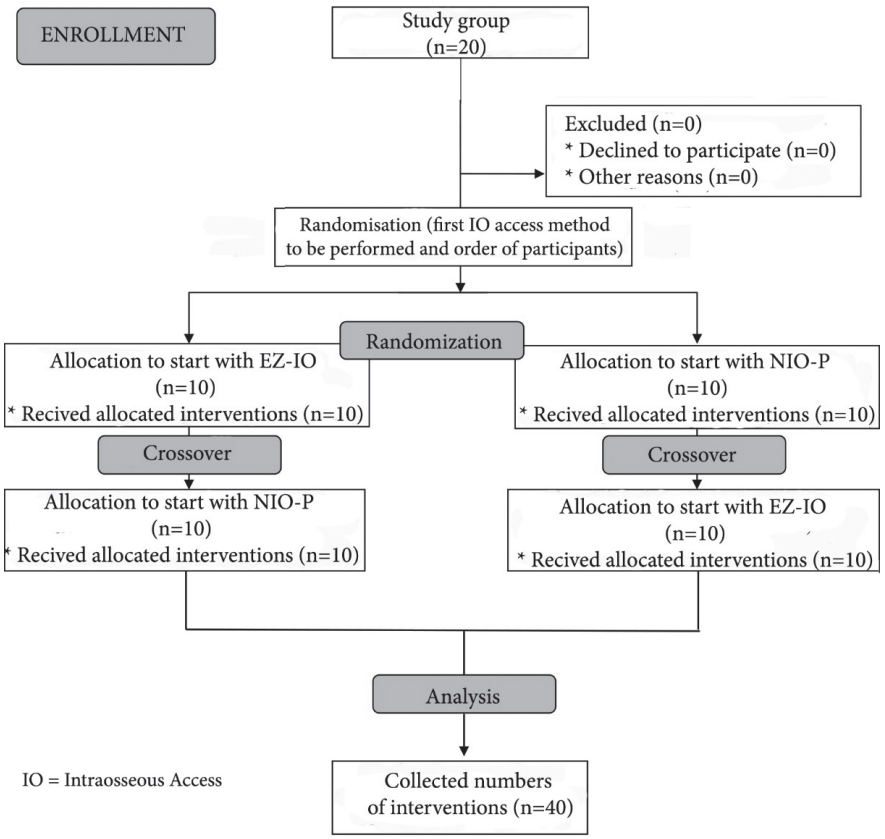

Figure 2. A flow chart presenting the study design and participants recruitment according to CONSORT statement

Results

The study involved 20 medical students in their final year after completion of emergency medicine curriculum, which were further subdivided into three--person teams.

The median time to obtain intraosseous access using EZ-IO was 23.5s [IQR: 18-32s] and NIO-P was 14.5s [IQR: 12-20s]. EZ-IO was longer and correlation for length of time was statistically significant (p = 0.014; figure 3).

Participants in the study using EZ-IO indicated the correct location of injection in 75% of cases, while in NIO-P the correct location of the injection site was 100% (p = 0.001).

The ease of use for NIO-P was 2 points [IQR: 1-2.5] and for EZ-IO 3 points [IQR: 2-3.5] (p = 0.007). The main difference between the two systems, which affected the ease of accessing the marrow was the insertion stabilizer in the NIO-P, which in principle facilitates localization of the pediatric injection site.

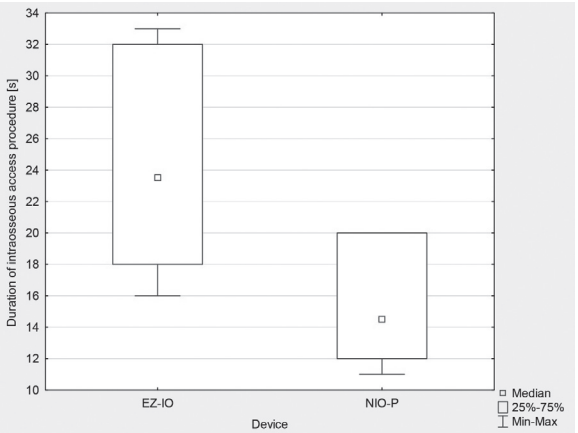

Figure 3. Time to obtain intraosseous access

Discussion

Intraosseous access is often the only alternative to intravenous access during cardiopulmonary resuscitation in the pre-hospital setting. During cardiopulmonary resuscitation, or in the event of hypovolemia, the vascular bed may be collapsed and obtaining intravenous access can cause difficulties to even the most experience emergency medical service teams. Repeated attempts to gain intravenous access may delay the delivery of fluids and medication, which in the event of sudden cardiac arrest, should be administered as soon as possible, meaning immediately after obtaining intravenous access. Buck et al. [12] indicated that intraosseous administration is a safe and effective method for delivering drugs during cardiopulmonary resuscitation.

In a number of studies, the authors compare the time and effectiveness of obtaining intravascular access, including peripheral and central vascular access. However, the number of studies for attaining IV access in the pediatric population is limited. Leidel et al. [13], compared the efficacy of intravenous and intraosseous access during adult CPR and found a higher efficacy and shorter time using intraosseous access compared to obtaining central venous line. Goldschalt et al. [14] compared the efficacy of obtaining IO and IV access in a dental office revealed that the chances to perform a successful vascular access for inexperienced dentists may be higher when using the tibial intraosseous route for emergency intravascular medication.

Studies evaluating the various types of intraosseous injections also largely indicate a superior advantage of NIO over other types of injections. Bielski et al. [15] evaluated the efficacy of four types of intraosseous injection devices performed by medical rescuers. The results of the study also pointed towards the advantages of NIO-P compared with EZ-IO, Pediatric BIG or Jamshidi. Shina et al. [16] showed that novice users were equally successful in establishing IO access with the NIO® in comparison to the EZ-IO® in a porcine model. The above results may be due to the fact that the injection using porcine models does not fully emulate the injection on a human body. Szarpak et al. [17], in a simulation study showed only a slight advantage of NIO-P over EZ-IO. It is important to emphasize that when inserting the NIO-P, the needle stabilizer is equipped with special points that provide the user optimal sites for injection.

When rapidly acquiring intraosseous access during cardiopulmonary resuscitation we are able to administer medication quicker. Similarly, in the meta-analysis from Ross et al. [18], it is shown that the time to administer the first dose of epinephrine was faster in the IO access group when compared to the peripheral intravascular access group.

This study has limitations. The first limitation is that the study was a medical simulation, however, this method of research was deliberately chosen as it allowed us to perform a cross-sectional, randomized study without bias for the potential patient. The second limitation was that the study was conducted by medical students in their final year, which was also not accidental, as physicians in their professional practice may encounter situations that require urgent administering of medication. Having no experience in obtaining intravenous access in the event of collapsed vasculature, intraosseous injection may be the only alternative for this group.

Conclusions

In the simulated study, final year medical students performing intraosseous access injection during cardiopulmonary resuscitation in the pediatric population, achieved faster access Times when using NIO-P compared to EZ-IO. NIO-P was also superior when locating the injection site and with ease of use.

Conflict of interest
None

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