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## Skills and attitudes toward intraosseous access in cardiopulmonary resuscitation among nursing personnel

### Umiejętności i postawy personelu pielęgniarskiego wobec wkłuć doszypikowych podczas resuscytacji krążeniowo-oddechowej

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#### Keywords

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#### Słowa kluczowe

zestaw wkłucia doszypikowego, wkłucie doszypikowe, resuscytacja krążeniowo-oddechowa, pielęgniarka, umiejętności

#### Conflict of interest

#### Konflikt interesów

None

Brak konfliktu interesów

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#### Summary

**Introduction.** Obtaining intravascular access in life-threatening conditions is one of the key procedures that the medical personnel should be able to perform. During cardiopulmonary resuscitation, when the blood vessels are collapsed, obtaining standard IV access may be difficult and may be associated with a delay in giving drugs and fluids to the patient.

**Aim.** The aim of the study was to compare the ability to perform intravascular access using a standard intravenous cannula and NIO and Jamshidi intraosseous devices during simulated cardiopulmonary resuscitation conducted by nurses.

**Material and methods.** The study was designed as a randomized, crossover study and was performed in the conditions of medical simulation. 64 nurses who took part in the Advanced Cardiopulmonary Life Support courses were enrolled in the study. The study analyzed both the time of obtaining intravascular access as well as the easiness of performing this procedure.

**Results.** The procedure time using distinct intravascular access methods varied and were respectively 34 s (IQR: 30-43) for intravascular access, 12 s (IQR: 11-15) for intraosseous access using NIO device, and 29 s (IQR: 23-38) for intraosseous access using Jamshidi needle. The statistical analysis revealed a statistically significant difference in the procedure time between NIO and IV cannula ( $p < .001$ ) and between NIO device and Jamshidi needle ( $p < .001$ ). The easiness of performing the procedure varied and scored: 1.5 points (IQR: 1-2.5) for NIO, 4 points (IQR: 2.5-4.5) for Jamshidi, and 4 points (IQR: 3-5.5) for intravenous cannula.

**Conclusions.** In the conducted study the nurses after short training were able to provide the intraosseous access with shorter time than intravascular. NIO device turned out to be the most effective among all the devices used in the study.

#### Streszczenie

**Wstęp.** Uzyskanie dostępu donaczyniowego w przypadku stanu zagrożenia życia u pacjenta jest jedną z kluczowych umiejętności, jaką winien wykazywać się personel medyczny. Podczas resuscytacji krążeniowo-oddechowej, gdy łożysko naczyniowe jest zapadnięte, uzyskanie dostępu dożylnego może być utrudnione i może wpływać na opóźnienie w podaży leków i płynów.

**Cel pracy.** Celem pracy było porównanie zdolności uzyskiwania dostępu dożylnego i doszypikowego z wykorzystaniem igły Jamshidi i wkłucia doszypikowego NIO podczas symulowanej resuscytacji krążeniowo-oddechowej.

**Materiał i metody.** Badanie zostało zaprojektowane jako randomizowane krzyżowe i przeprowadzone w warunkach symulacji medycznej. W badaniu wzięły udział

64 pielęgniarki uczestniczące w kursie Advanced Cardiopulmonary Life Support. Podczas badania analizowano czas uzyskania dostępu donaczyniowego oraz łatwość wykonania procedury.

**Wyniki.** Czas trwania procedury uzyskania dostępu donaczyniowego był zróżnicowany i wynosił odpowiedni 34 s (IQR: 30-43) dla wkłucia dożylnego, 12 s (IQR: 11-15) dla wkłucia doszpikowego z wykorzystaniem NIO oraz 29 s (IQR: 23-38) dla wkłucia doszpikowego z wykorzystaniem igły Jamshidi. Analiza statystyczna wykazała istotne statystyczne różnice w czasie trwania procedury pomiędzy NIO i wkłuciem dożylnym ( $p < 0,001$ ) oraz pomiędzy NIO i igłą Jamshidi ( $p < 0,001$ ). Łatwość wykonania procedury była zróżnicowana i wynosiła odpowiednio: 1,5 punktu (IQR: 1-2,5) dla NIO, 4 punkty (IQR: 2,5-4,5) dla igły Jamshidi oraz 4 punkty (IQR: 3-5,5) dla wkłucia dożylnego.

**Wnioski.** W przeprowadzonym badaniu, pielęgniarki już po krótkim szkoleniu były w stanie uzyskiwać dostęp doszpikowy w czasie krótszym aniżeli miało to miejsce w przypadku dostępu dożylnego. NIO było najbardziej efektywnym spośród badanych urządzeń.

## INTRODUCTION

The ability to obtain intravascular access in life-threatening conditions is one of the key procedures that the medical personnel should be able to perform. Sudden cardiac arrest, anaphylactic shock or hypovolemic shock are only some of the situations of sudden cardiac arrest, which require immediate intravascular access and pharmacotherapy. In the case of cardiopulmonary resuscitation and non-fibrillative rhythms in cardiac arrest – advanced resuscitation procedures also include giving the adrenaline as soon as possible. However, in cases where the vessels are collapsed, peripheral vein cannulation may be difficult or often even impossible to perform.

Intraosseous access is currently the first recommended vascular access in pediatric emergencies such as cardiac arrest or hypovolemic shock, although it is only ranked as the first alternative to intravascular access for adult cardiac arrest (1-4). The medullar cavities of the proximal tibia or the head of humerus are the most commonly used locations for intraosseous access. Pharmacokinetic and pharmacodynamics studies showed that the intraosseous route is equivalent to intravenous access for administration of radionuclide tracers and emergency drugs such as vasoactive drugs (5, 6).

## AIM

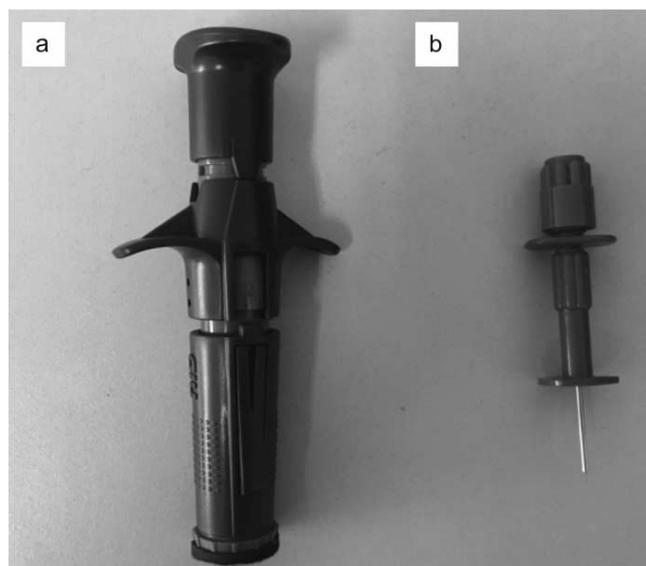
The aim of this study was to compare the overall time needed for establishing the intraosseous access with the NIO device and Jamshidi needle compared to the overall time for obtaining the peripheral intravenous access, performed by nurses during simulated cardiopulmonary resuscitation.

## MATERIAL AND METHODS

This prospective, randomized, crossover observational study was conducted between November 2017 and January 2018. The Institutional Review Board of the Polish Society of Disaster Medicine (Approval number: 32.2017.IRB) approved the study protocol.

The study used a comparison of intravenous access, during which it was recommended to cannulate the median cubital vein according to the rules of aspira-

tion and antisepsis. In the case of intraosseous access, two devices were used: semi-automatic NIO Adult device and a Jamshidi needle, the access was obtained through the proximal part of the tibia (fig. 1a, b). The procedure of obtaining intraosseous access was also performed with the principles of asepsis and antiseptics.



**Fig. 1a, b.** Intraosseous devices used in the study: (a) NIO Adult Device, (b) Jamshidi needle

Prior to the study, all participants took part in the course regarding the obtaining the intraosseous access. During the training, the instructor discussed and demonstrated the correct way of obtaining access with the aforementioned devices. The study participants did not take part in the practical part.

Immediately after completing the theoretical part, the study participants were divided in three groups, the first one started with obtaining the intravenous access with a standard intravenous cannula, the second group performed intraosseous access with NIO Adult, the third group used the Jamshidi needle. After 20-minute breaks, participants of the study performed intravascular access with another method. A detailed randomization procedure is presented on figure 2.

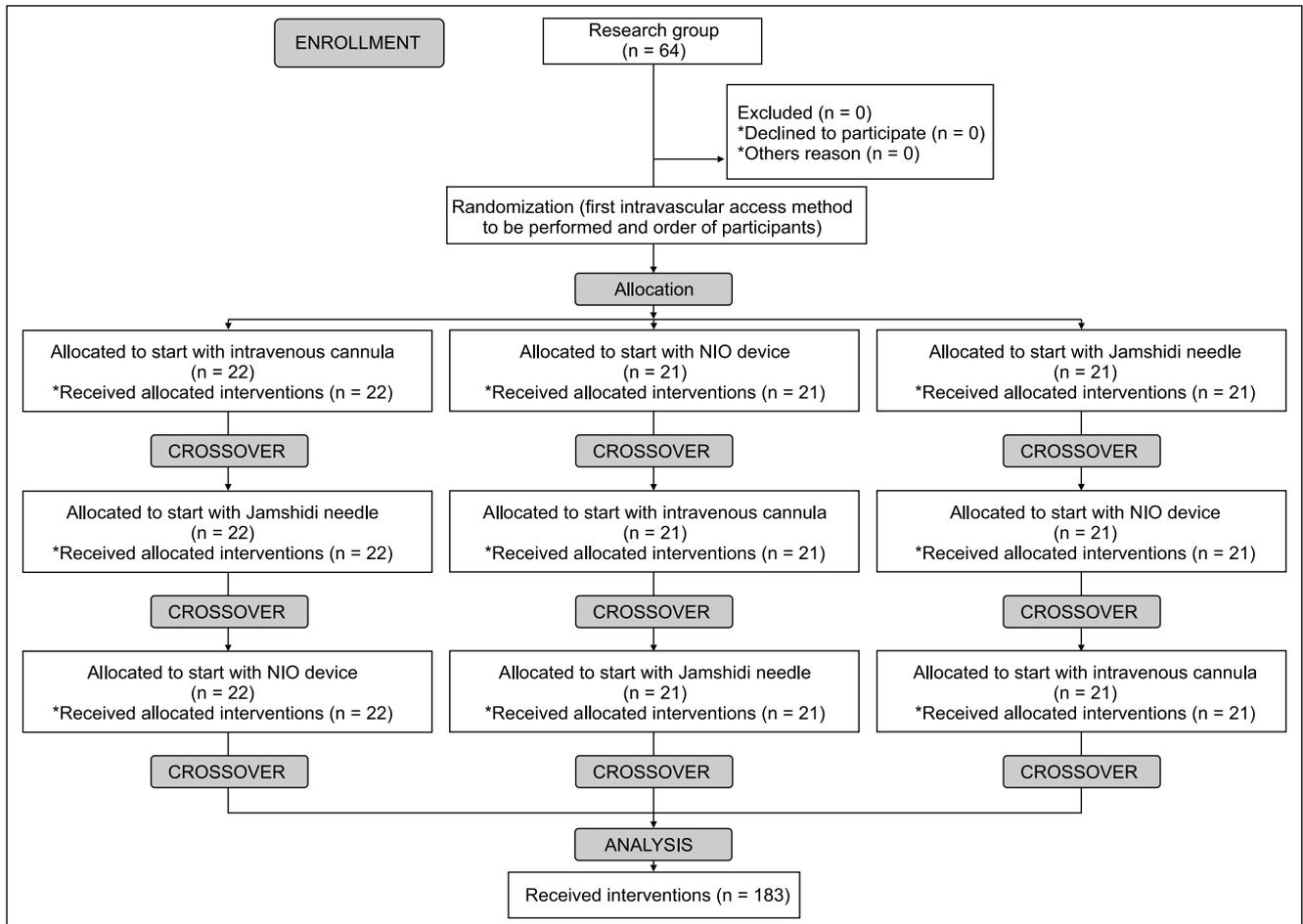


Fig. 2. Randomization flow chart of the study

The procedure of obtaining the vascular access was performed in the simulated cardiopulmonary resuscitation environment. In order to simulate a patient with cardiac arrest, the Advanced Skill Trainer training manikin was used (Laerdal, Stavanger, Norway). To make the scenario appear more real, cardiopulmonary resuscitation was carried out in accordance with the advanced resuscitation procedures. Additionally, the LUCAS 3 mechanical chest compression system was used to optimize chest compressions.

The primary endpoint was the time of providing the patient with the intravascular access. The time was measured from the moment of taking the device to the moment of aspiration with the syringe. Another parameter measured during the study was the easiness of obtaining intraosseous access, which was measured in a 10-degree scale ranging from “1” – very easy to the “10” very difficult. For statistical analysis STATISTICA 12 (STATSOFT, Tulusa, USA) statistical package was used. A p value of < 0.05 was considered statistically significant.

## RESULTS

In the study 64 nurses were enrolled. Median age was 49 years (IQR: 38-53) and the median work experience was 24 years (IQR: 12-28). None of the participant had a prior experience with the intraosseous access.

The procedure times using various intravascular access methods varied and were 34 s (IQR: 30-43) for intravascular access, 12 s (IQR: 11-15) for intraosseous access using NIO device, and 29 s (IQR: 23-38) for intraosseous access using Jamshidi needle, respectively. The statistical analysis revealed a statistically significant difference in the procedure time between NIO and IV cannula ( $p < .001$ ) and between NIO device and Jamshidi needle ( $p < .001$ ; fig. 3). The efficacy of venous vessel cannulation was 100%, and it was the same when obtaining the intraosseous access using NIO and Jamshidi needle measured by the correctness of the location of the intraosseous entry point. The correctness of the intraosseous needle placement was also 100% for both devices.

The easiness of performing the procedure varied among the devices and amounted to: 1.5 points (IQR: 1-2.5) for NIO, 4 points (IQR: 2.5-4.5) for Jamshidi needle and 4 points (IQR: 3-5.5) for intravenous cannula. 100% of participants during the real life resuscitation would perform intraosseous access with NIO device.

## DISCUSSION

In the conducted study we made an attempt to evaluate three techniques for obtaining intravascular access during simulated cardiopulmonary resuscitation by nurses. The results indicate the advantage of

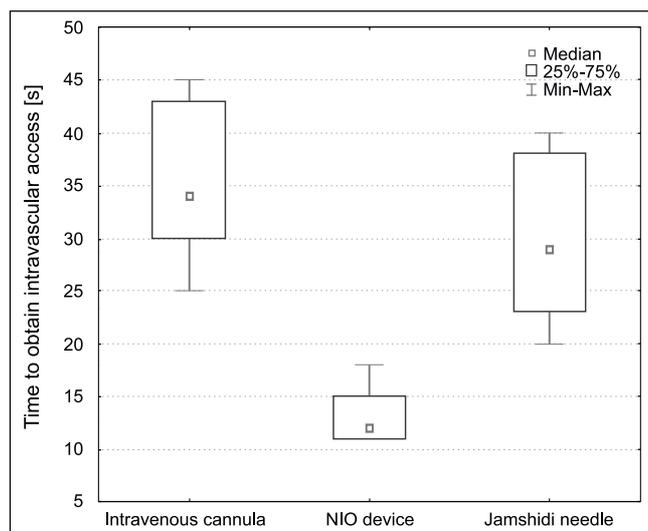


Fig. 3. Median time to obtain intravascular access

intraosseous access over intravenous access, both in the efficacy and the duration of the procedure.

Jones et al. (7) reported an overall 84% sternal intraosseous access success rate. The effectiveness of the first attempt of obtaining the intraosseous access among inexperienced paramedics was 74 and 95% in the case of paramedics with the prior experience in providing intraosseous access. In the study by Szarpak et al. (8) the success rate of the first IO attempt was 89.3% for tibial access and 73.8% for humeral access. However a study by Bielski et al. (9) demonstrated that the efficacy of intraosseous access in a pediatric patient was at 90% rate for the intraosseous access with BIG, EZ-Io and Jamshidi needle. The NIO device achieved a 100% efficacy rate. As the research by Paxton et al. (10) which was comparing the efficacy of various techniques for obtaining intravascular access in cardiopulmonary resuscitation, the efficacy rate of the intraosseous entry attempt was 81%, for peripheral intravenous access it was 74%, and the efficiency rate for central venous cannulation was 20%.

A study by Leidel et al. (11) showed that the effectiveness rate of the first attempt of obtaining intraosseous access was at 85 vs. 60% for the central vessels cannulation. In the conducted study, the shortest duration of the procedure was obtained with the use of NIO intraosseous entry. Bielski et al. (9) also confirms those findings in his study, where he compared the four types of achieving intraosseous access. The study showed a median time of intraosseous puncture with the use of NIO device with 9 s (IQR: 8-12), while for Jamshidi needle, this time was 15 s (IQR: 13-19). Obtaining vascular access in the event of cardiac arrest when the vessel

is collapsed and obtaining intravenous access may be difficult and take more time. Paxton’s study indicates that obtaining access to the peripheral vein took 3.6 min while it took 15.6 min for cannulating of central vessel. In Leidel’s study (11) the times were 2 and 8 min respectively. Taking into the consideration the fact that in the case of cardiac arrest with non-fibrillation rhythms, such as pulseless electrical activity (PEA) or asystole – the key element of resuscitation is obtaining of intravascular access and providing the patient with adrenaline delivery as soon as possible. Also in other clinical cases e.g. anaphylactic or hypovolemic shock, immediate access to intravascular access and providing the patient with both drugs supply and fluid resuscitation are critical for the patient’s condition. Several studies present the complications of intraosseous access (12-18). Among them we can list: iatrogenic bone fracture, compartment syndrome, osteomyelitis, grown plate disruption, hematoma formation, tissue necrosis or fat embolization. However, the aforementioned complications concern a very small percentage of patients and intraosseous access is gaining wider significance, not only during cardiopulmonary resuscitation. Many studies indicate the use of intraosseous access in various conditions e.g. hemorrhages for the supply of Tranexamic acid (19), during computed tomography to supply radiocontrast (20-22) or to supply the anesthetics (23).

The study showed that the people without prior experience in performing intraosseous access are able to perform this procedure after a short training. This finding is confirmed by the Polat et al. (24), who indicated that the learning curve this access is 3-4 attempts under the supervision of experienced instructors.

The study has several limitations. The first one is that the study was conducted in the simulated environment with the use of training dummies instead of people. However, this method of performing the study allows for performing the cross-over randomized study without the potential harm to a real patient. Additionally, the efficacy of intraosseous access was evaluated in the study, based on the correct location of the intraosseous access and the correctness of insertion of the intraosseous needle, whereas during real life study, it would also require confirmation by the bone marrow aspiration. The results of this study require further confirmation with the cadaver or in real-life studies.

### CONCLUSIONS

In the conducted study the nurses after short training were able to provide the intraosseous access with shorter time than intravascular. NIO device turned out to be the most effective among all the devices used in the study.

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