Czyż Rafał, Leśkiewicz Marcin, Górniak Izabela, Wudarczyk Beata. Current advances in intraosseous access - a review of presently available devices. Journal of Education, Health and Sport. 2018;8(8):939-950 eISNN 2391-8306. DOI http://dx.doi.org/10.5281/zenodo.1406964
http://ojs.ukw.edu.pl/index.php/johs/article/view/5892

The journal has had 7 points in Ministry of Science and Higher Education parametric evaluation. Part b item 1223 (26/01/2017).
1223 Journal of Education, Health and Sport eissn 2391-8306 7

The authors declare that there is no conflict of interests regarding the publication of this paper.

Received: 02.06.2018. Revised: 18.06.2018. Accepted: 31.08.2018.

Current advances in intraosseous access - a review of presently available devices

Rafał Czyż[1], Marcin Leśkiewicz[2], Izabela Górniak[3], Beata Wudarczyk[4]

[1]Department of Emergency Medicine, Wroclaw Medical University

[2]Department of Emergency Medical Services, Wroclaw Medical University

[3]Graduate of Wroclaw Medical University

[4]Department of Nursing, Faculty of Medicine and Health Science, University of Zielona Góra

Rafał Czyż - orcid - http://orcid.org/0000-0001-5504-4543

Beata Wudarczyk - orcid - https://orcid.org/0000-0003-0495-8630

Marcin Leśkiewicz - orcid - http://orcid.org/0000-0003-0167-1618

Izabela Czyż - orcid - http://orcid.org/0000-0002-7838-1670

Address for correspondence:

Rafał Czyż, Department of Emergency Medicine Wroclaw Medical University, Wrocław. Poland; e-mail: rafalczyz1990@o2.pl

Abstract

Quickly obtained and effective access to the patient's circulatory system is a very important element of advanced life support procedures that save the patient's life both in pre-hospital and hospital conditions. However, the classic intravascular injection method can often prove

ineffective or even impossible to perform. In such situations, it may be helpful to use intraosseous needle set device.

Aim of this article is to present selected intraosseous access devices, which could improve quality of care under patient in critical state. Examples of such devices are: Dieckmann modified needle, EZ-IO® Manual Needle Set, EZ-IO® T.A.L.O.N.™ Needle Set, Jamshidi Needle, Bone Injection Gun (B.I.G), New Intraosseous device (NIO), FAST Responder IO device, Arrow Ez-IO Intraosseous Vascular Access System.

The ready-to-use intraosseous devices sets are an excellent and easy to use alternative to traditional peripheral intravenous access.

Key words: intraosseous access, emergency medicine, critical care medicine, Emergency Medical Service

Introduction

Quickly obtained and effective access to the patient's circulatory system is a very important element of advanced life support procedures that save the patient's life both in pre-hospital and hospital conditions. However, the classic intravascular injection method can often prove ineffective or even impossible to perform. Difficulty in inserting an intravenous access may result from: the severity of the patient's clinical condition, lack of proper preparation of the staff to perform the puncture, lack of sufficient access to the patient (patient trapped in a vehicle as a result of a traffic accident) and many other variables. In such situations, it may be helpful to use a intraosseous needle set device. Scientific research confirms that the drugs administered by the intraosseous needle reach plasma concentration in a time comparable to the drugs given to the catheter placed in the central vein [1-3]. It was also confirmed that the use of a ready to use intraosseous device significantly shortened the time to access the circulatory system in comparison with intravenous injection [4-6]. It is also important that both the European Resuscitation Council and the American Heart Association recommend the use of intraosseous access in circumstances where intravenous access is not as easy to obtain in a timely manner [7,8].

Aim of the research

The aim of this article is to present selected intraosseous access devices which could improve quality of care under patient in critical state with a particular focus on:

- Dieckmann modified needle (Cook Medical Incorporation, Bloomington, IN, USA)
- EZ-IO® Manual Needle Set (Vidacare, Shavano Park, TX, USA)
- EZ-IO® T.A.L.O.N.™ Needle Set (Vidacare, Shavano Park, TX, USA)
- Jamshidi Needle (CareFusion Co., San Diego, CA),
- Bone Injection Gun - B.I.G (Waismed Limited, New York, NY, USA),
- New Intraosseous device - NIO (Persys Medical, Houston, TX, USA),
- FAST Responder Sternal Intraosseous Device (PYNG Medical Co., Richmond, BC)
- Arrow Ez-IO Intraosseous Vascular Access System (Vidacare, Shavano Park, TX, USA)

Description of knowledge

All devices for intraosseous access available on the market can basically be divided into three main groups. A feature that differentiates these devices is the type of mechanical drive used. In this way, we stand out: Manual Device, Spring Devices and Drill-based systems.

Manual Devices

Manual devices are the most basic intraosseous devices which require from the user significant physical strength to manually insert the needle into the patient's medullary cavity. Examples of such devices are: Dieckmann modified Needles, EZ-IO® Manual Needle Set, EZ-IO® T.A.L.O.N.™ Needle Set and Jamshidi Needle. All of these devices are equipped with a handle that provides a secure grip. In addition, the device consists of a needle with a guide inside, which after successful introduction into the medullary cavity should be removed. The tip of the needle is appropriately beveled to ensure easier insertion of the needle, increase patient safety as well as ensure controlled insertion of the needle. Despite the fact that manual devices are relatively cheap, the main drawback of these devices is the fact that they require the use of a force method. What is important, there were cases of bending the needle when trying to insert the needle by applying too much force [9]. Therefore, they are mainly used for intraosseous access in pediatric patients, where this procedure can be performed safer and more effectively due to the softer tissues. All manual intraosseous devices are single-use.

Dieckmann modified Needle

The feature that distinguishes this device from others is the fact that there are holes at the end of the needle on both sides. Their aim is to ensure the free flow of fluids and medicines administered. Additionally, it is available in various sizes of thickness and length of the needle [10]:

- 14 Needle Gage – 3.0 cm Needle Length
- 16 Needle Gage – 3.0 cm Needle Length
- 16 Needle Gage – 4.0 cm Needle Length
- 18 Needle Gage – 3.0cm Needle Length

Dieckmann modified Needle has been designed for use in 3 anatomical locations of the patient [10]:

- Proximal tibia - antero-medial surface of Tibia 1-3 cm below Tibial Tuberosity
- Distal tibia - medial surface of the Tibia Proximal to the medial Malleolus
- Distal femur - Alternative place if proximal or distal tibia is unsuitable

EZ-IO® Manual Needle Set

It is a device adapted for use in all patients weighing 3 kg and more [11]. The manufacturer of this device anticipates using it in such locations on the patient's body as:

- Proximal humerus,
- Proximal tibia
- Distal tibia

EZ-IO® T.A.L.O.N.™ (Tactically Advanced Lifesaving IO Needle) Needle Set

It is an example of a manual intraosseous device, which has been adapted by the manufacturer to be installed in the sternum, proximal humerus, proximal tibia, distal tibia. By adding an appropriate adhesive stabilizer to the patient sternum, the equipment is completely safe and allows to give the patient high volumes of fluids with a well speed directly to the sternum [12,13].

Jamshidi Needle

It is the device best known among manual intraosseous access. In terms of construction, it is worth emphasizing that this device has luer slip / luer lock connection for a secure fit to

any syringe. What is more adjustable depth guard to help control the depth in needle insertion [14].

This device is produced in two sizes of the needle:

- Needle Gage - 15 G adjustable length from 24mm to 48mm - for 9 months or older patients
- Needle Gage - 18 G adjustable length from 14mm to 48mm - for younger than 9 months

Producer of Jamishidi Needle recommends using it only in these three anatomical places: [14]:

- Proximal tibia - can be used in children up to 6 years of age
- Distal tibia - preferred place for older children
- Distal femur

Spring Devices

This type of devices has been designed to facilitate the possibility of getting an intraosseous access. Thanks to the spring mechanism, the devices fired the needle like a projectile and placed it precisely in the medullary cavity. The whole procedure is performed by the medic without putting any of extra strength. It is only necessary to: properly locate the appropriate injection place, prepare the skin surface well, apply the device on the patient and most importantly release the lock from the stretched spring, for an effective firing of the needle. Due to the proper adaptation of the device, it is not necessary to set the appropriate force of the needle firing. Simplicity in using such devices does not eliminate the necessity to complete specialist training which should consist of theoretical classes and practical training in technical skills. Importantly, all manufacturers of this type of equipment, in addition to the real version, also have a training version with manikins that simulate the anatomical region for the insertion of this device. Scientific research of many authors shows that devices based on a spring mechanism are assumed by the participants in a shorter time and with greater efficiency than mechanical devices [6,15]. Examples of such devices are: Bone Injection Gun (B.I.G), New Intraosseous device (NIO) and FASTResponder Sternal Intraosseous Device.

Bone Injection Gun (B.I.G)

Bone Injection Gun device is easy to use thanks to the spring mechanism used. B.I.G is made of hard plastic, and the needle is completely enclosed and invisible, which increases safety and patient comfort. In addition, the device is secured against accidental release of the lock by

a characteristic red clip located on the top of the device. B.I.G device is available in two versions [28]:

- Adult version (blue color) - Needle Gage - 15 G
- Pediatric version (red color) - Needle Gage - 18 G

Adult version is recommended for patient from 12 years of age. Pediatric version is adapted for patients from birth to 12 years of age. It is important that B.I.G-Pediatric should be prepared before use with child. It is based on choosing one of the age range in which the patient is. This should be done by unscrewing the needle guard. Three age ranges are available and are associated with the appropriate needle penetration [27]:

- 0 – 3 years - 0.5 cm – 1.0 cm depth of needle penetration
- 3 – 6 years - 1.0 cm – 1.5 cm depth of needle penetration
- 6 – 12 years - 1.5 cm depth of needle penetration

Bone Injection Gun device is recommended to use at the upper tibia plateau in adult and also in pediatric patient.

New Intraosseous device (NIO)

The New Intraosseous device as the name suggests is quite new device available on the market. Its operation is also based on a spring mechanism. In relation to B.I.G, the manufacturer improved the method of stabilizing the needle after placing it in the medullary cavity. In the B.I.G device, to protect the needle from accidental removal is a red clip the same one which earlier task was to protect the equipment from unplanned release of the spring lock. In the NIO device, the needle descends from the handle of the device and entails a special tip, which creates a stabilizing collar on the patient's skin, which should finally be wrapped with a special veneer attached to the set [22]. As in the B.I.G device in NIO device, there are also two versions of the device:

- NIO-Adult ™ - blue color
- NIO-Pediatric ™ - red color

NIO-Pediatric has two degrees of needle penetration depth adjustment and is dependent on the child's age [23]. According to the manufacturer's instructions, after removing the equipment from the packaging, NIO-Pediatric is ready to be placed on a child between the ages of 9 and 12 years. By properly unscrewing the tip of the handle, it will be possible to adapt this device also for a patient from 3 to 9 years of age. NIO-Pediatric is not recommended for use in children under 3 years of age. In order to facilitate the placement of the NIO-Pediatric device

and eliminate the probability of making a mistake when placing it on a child, the manufacturer placed special arrows on the top of the device. Placing the arrow just under the tibial tuberosity causes a perfect and very accurate positioning of the device in the correct anatomical site [23]. The device manufacturer also took care of the high standard of training by creating an innovative training device - NIO-SIMulation ™ (yellow color) [24]. This device has reduced trocar and cannula length, so students can use the device on each other completely safely. It can also be used on any type of manikin without damaging it. The training version is available in both the adult and pediatric versions.

FAST Responder Sternal Intraosseous Device

FASTResponder Sternal IO device is one of the few devices which recommended place to locate is upper part of the sternum. In addition, thanks to the appropriate notch at the top of the handle, which allows user to quickly and unambiguously determine the correct location of the planned puncture place, the authors estimate that the time to correctly install the device in most cases does not exceed 10 seconds [19]. Despite the fact that it may seem that the device placed on the sternum may interfere with conducting chest compressions in a patient with cardiac arrest, scientific research does not confirm this [20]. In addition, there were no contraindications to use of automated chest compression devices together with FASTResponder Sternal Intraosseous Device. Like the B.I.G and NIO devices, FASTResponder also automatically punctures the needle at the appropriate depth, so that the user does not have to choose the right size of the needle. In addition, the low profile of the correctly installed device reduces the chances of accidental and unintentional removal of the puncture during patient transport. As a big advantage of the FASTResponder device, it can be considered that among all the intraosseous devices it provides the most effective flow of transfused volumes [21]. In Hammer et.al. research authors state that the one-minute gravity infusion had a flow rate of 53 ± 2 ml / min, and when using the rapid transfusion set with a 300 mmHg pressure force, a flow of 112 ± 47 ml / min was obtained [21].

Drill-based system

Devices operating on this type of drive are easier and more intuitive to use, but require from the user to break the internal psychological barriers associated with drilling into human tissue. Psychological barriers can be the biggest problem in the dissemination and use of such devices. The advantage of the grill-based system is the fact that they can be used in more anatomical places. They consist of a reusable drill and disposable, sterile needles.

Arrow® EZ-IO® Intraosseous Vascular Access System

It is one of the few devices using a drill-based system. It consists of a handy drill and interchangeable needles placed on the top of it. Getting access in a few seconds, flow up to 5 l/hour and time getting fluids to the heart within even 3 seconds are invaluable values in critical situations in which every second matters [26]. The manufacturer of this device attaches three standard needles to the set [25]:

- 15 mm Needle – 15 G - for patients weighing from 3 to 39 kg
- 25 mm Needle – 15 G - for patients weighing over 39 kg
- 45 mm Needle – 15 G - for obese patients or patients with excessive tissue over the insertion site (excess tissue from edema, large musculature or obesity)

The Arrow EZ-IO device is recommended for use in anatomical places such as [25]:

For adults:

- Distal tibia
- Proximal tibia
- Proximal humerus

For pediatric patients:

- Proximal humerus
- Proximal tibia
- Distal tibia
- Distal femur

Many research authors emphasize the rationale of using a rapid transfusion kit that optimizes the infusion rate of a patient in a critical condition [16-18].

Summary

The ready-to-use intraosseous devices sets are an excellent alternative to traditional peripheral intravenous access. Thanks to their use, it is possible to give the right medicines or start fluid therapy in a shorter time even in a pediatric patient or in a state of cardiac arrest. Scientific research confirms that these devices are safe for the patient as well as for medical personnel, they are effective and easy to use. Unfortunately, one relatively basic disadvantage of these devices is their relatively high purchase cost. On the other hand, these devices require adequate theoretical knowledge and training to function well and be effectively configured. Medical personnel should be systematically trained in this field with additional consideration of such

aspects as: indications, contraindications to the establishment of intraosseous access, possible complications as well as limitations of this type of access to the circulatory system.

References

[1] - Carness J.M, Russell J.L, M e Lima R, et al.: Fluid resuscitation using the intraosseous route: infusion with lactated Ringer's and hetastarch. Mil Med. 2012; 177; 2: 222-228.

DOI: 10.7205/MILMED-D-11-00195, indexed in Pubmed: 22360071.

[2] - Hoskins S.L, do Nascimento Jr. P, Lima R.M, et al.: Pharmacokinetics of intraosseous and central venous drug delivery during cardiopulmonary resuscitation. Resuscitation. 2012; 83: 107-112.

DOI: 10.1016/j.resuscitation.2011.07.041, indexed in Pubmed: 21871857.

[3] - Burgert J, Gegel B, Loughren M, et al.: Comparison of tibial intraosseous, sternal intraosseous, and intravenous routes of administration on pharmacokinetics of epinephrine during cardiac arrest: a pilot study. AANA J. 2012; 80; (4): 6-10.

Indexed in Pubmed 23248824.

[4] - Hartholt K.A, van Lieshout E.M, Thies W.C, et al.: Intraosseous devices: a randomized controlled trial comparing three intraosseous devices. Prehosp Emerg Care. 2010; 14; 1: 6-13.

DOI: 10.3109/10903120903349861, indexed in Pubmed: 19947861.

[5] - Leidel B.A, Kirchhoff C, Braunstein V, et al.: Comparison of two intraosseous access devices in adult patients under resuscitation in the emergency department. Resuscitation. 2010; 81; 8: 994-99.

DOI: 10.1016/j.resuscitation.2010.03.038, indexed in Pubmed: 20434823.

[6] - Bielski K, Szarpak Ł, Smereka J, et al.: Comparison of four different intraosseous access devices during simulated pediatric resuscitation. A randomized crossover manikin trial. Eur J Pediatr. 2017; 176; (7): 865-71.

DOI: 10.1007/s00431-017-2922-z, indexed in Pubmed: 28500463.

[7] - Soar J, Nolan JP, Böttiger BW, et al.: European Resuscitation Council Guidelines for Resuscitation 2015 Section 3. Adult advanced life support. Resuscitation. 2015; 95: 100-147.

DOI: 10.1016/j.resuscitation.2015.07.016, indexed in Pubmed: 26477701.

[8] - Link MS, Berkow LC, Kudenchuk PJ.: Part 7: Adult Advanced Cardiovascular Life Support: 2015 American Heart Association Guidelines Update for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care. Circulation. 2015; 3; 132: 444-64.

DOI: 10.1161/CIR.0000000000000261, indexed in Pubmed: 26472995.

[9] - Hafner J.W, Bryant A, Huang F, et al.: Effectiveness of a Drill-assisted Intraosseous Catheter versus Manual Intraosseous Catheter by Resident Physicians in a Swine Model. West J Emerg Med. 2013; 14 (6): 629-32.

DOI: 10.5811/westjem.2013.4.13361, indexed in Pubmed: 24381684

[10] - https://www.cookmedical.com/data/resources/4%20CC-BM-EMB-EN-201103.pdf (access: 10.08.2018)

[11] - https://www.narescue.com/fileuploader/download/download/?d=1&file=custom%2Fupload2F30-0078_EZIOExtremity_PIS.pdf_1511290829.pdf (access: 10.08.2018)

[12] - https://www.narescue.com/fileuploader/download/download/?d=1&file=custom%2Fupload%2F30-0132_TALON-Manual-Needle-Set_PIS.pdf_1512139193.pdf (access: 10.08.2018)

[13] - Philbeck T.E, Puga T, Montez D. F.: 135 Sternal Flow Rates and Insertion Success Using a Multisite Intraosseous Device. Annals of Emergency Medicine. 2015; 66 (4): 48. DOI: https://doi.org/10.1016/j.annemergmed.2015.07.167.

[14] - https://www.quadmed.com/files/06d9ac7f-79ab-4002-9637-485502089b06.pdf (access: 10.08.2018)

[15] - Kurowski A, Timler D, Evrin T, et al.: Comparison of 3 different intraosseous access devices for adult during resuscitation. Randomized crossover manikin study. Am J Emerg Med. 2014; 32 (12):1490-3. DOI: 10.1016/j.ajem.2014.09.007, indexed in Pubmed: 25440232.

[16] - Ong M.E, Chan Y.H, Oh J.J, Ngo A.S.: An observational, prospective study comparing tibial and humeral intraosseous access using the EZ-IO. Am J Emerg Med. 2009; 27: 8-15. DOI: 10.1016/j.ajem.2008.01.025 , indexed in Pubmed: 19041528.

[17] -Macnab A, Christenson J, Findlay J, et al.: A new system for sternal intraosseous infusion in adults. Prehosp Emerg Care. 2000; 4: 173-77. DOI: 10.1016/S0196-0644(05)80199-4, indexed in Pubmed: 10782608.

[18] -Halvorsen L, Bay B.K, Perron P.R, et al.: Evaluation of an intraosseous infusion device for the resuscitation of hypovolemic shock. J Trauma. 1990; 30: 652-58. DOI: 10.1016/S0196-0644(99)80336-9, indexed in Pubmed: 1693696.

[19] - Byars D.V, Tsuchitani S.N, Erwin E, et al.: Evaluation of success rate and access time for an adult sternal intraosseous device deployed in the prehospital setting. Prehosp Disaster Med. 2011; 26 (2): 127-9. DOI: 10.1017/S1049023X11000057., indexed in Pubmed: 21888733.

[20] - http://qrs.nl/wp-content/uploads/2016/01/Sternal_IO_eBook_Feb_2016.pdf (access: 10.08.2018)

[21] -Hammer N, Möbius R, Gries A, et al.: Comparison of the Fluid Resuscitation Rate with and without External Pressure Using Two Intraosseous Infusion Systems for Adult

Emergencies, the CITRIN (Comparison of InTRaosseous infusion systems in emergency medicINe)-Study. PLoS One. 2015; 10 (12): e0143726.
DOI: 10.1371/journal.pone.0143726, indexed in Pubmed: 26630579.

[22] - http://ps-med.com/wp-content/uploads/2018/03/NIO-A-Spec-Sheet.pdf (access: 10.08.2018)

[23] - http://ps-med.com/wp-content/uploads/2018/03/NIO-P-Spec-Sheet.pdf (access: 10.08.2018)

[24] - https://www.pelegrinamedical.com/Literaturas/Persys%20Medical/NIO-SIM-Spec-Sheet.pdf (access: 10.08.2018)

[25] - https://www.teleflex.com/emea/documentLibrary/documents/940774-000001_VA_EZ-IO_Pocket_Guide_BR_1709.pdf (access: 10.08.2018)

[26] - http://www.paramedica.pl/zalaczniki/EZ-IO%2005%2016%20wer%2001%20Mejl.pdf (access: 10.08.2018)

[27] - http://www.implox.com.au/content/pdfs/big_new2013.pdf (access: 10.08.2018)

[28] - http://ps-med.com/products/vascular-access/bone-injection-gun-pediatric/ (access: 10.08.2018)