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Intraosseus access vs ecoguided peripherical venous access in emergency and urgency: a systematic review

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Abstract. *Background and aim:* Ensuring vascular access in emergency conditions is critical. Peripheral venous catheters (CVP) are the most used devices in clinical practice, even though their positioning can result difficult, causing delay in life-support treatments with possible critical results. Ultrasounds allow you to view blood vessel in real time, for this reason they could result helpful during use. Another option for the vascular access can be intraosseous access (I.O.), by introducing a needle directly in the bone marrow cavity. This review aim is to examine what typology of vascular access is best for the drug delivery in emergency/urgency in international and national literature. *Methods:* Bibliographical research was conducted by consulting the main biomedical databases through keywords and MESH terminology. In this review 21 articles published in the last 7 years have been included. They were published in English, Italian and French. *Results:* Contraindications and complications of I.O and of ultrasound-guided CVP positioning are limited. I.O access finding attempts are as fast as CVP positioning attempts but with a higher chance of success. Furthermore, ultrasound-guided CVP insertion is more comfortable for patients, it minimizes delays in medical treatment and it guarantees a better healthcare, with high percentage of right venous catheter placement. *Conclusions:* Intraosseous access is recommended for severely compromised patients; the ultrasound guide is a very useful tool when peripheral vascular areas are difficult to detect with only the palpation, it would be more appropriate in situations of urgency than that of emergency.

Key words: Ultrasound-guided, peripheral venous catheter, peripheral venous access, vascular access devices, emergency, intraosseous, intraosseous vascular access, catheterization

Introduction

Prompt action is the first factor that affects the result, in medical emergency/urgency. Moreover, it is also important the quality of the assistance, since the importance of golden rule is amplified in treatment and inspection of patients in impending danger of death. This rule prevents wasting of time with useless and ineffective operations, while it implements successful interventions in a really short time, by following a based-on-adequacy priority order (1).

At this point, it is important to make a difference between emergency and urgency. "Emergency" is the condition in which survival is at stake and immediate actions are needed within minutes, in order to support and restore patients' vitals (1).

"Urgency" is the condition in which prompt actions are required within a few hours, therefore not as immediate as in case of emergency, (1).

It is essential to ensure a vascular access in order to act/take action in urgency-emergency. Peripheral venous catheter (CVP) are the most used vascular

access devices in medical practice for parenteral administration of liquids and nutrients, drugs and blood products (2).

However, finding a peripheral vascular access could be difficult, in order to deal with medical emergency, because it could waste medical staff precious time. Literature data report that, in certain instances, it takes from 3 to 12 minutes and failure rates range between 10 and 40%. The causes of such failure could be related to a state of shock (with peripheral veins collapse), the peculiarity of each patient (such as obesity) or difficulties linked to environmental situation (for instance a patient locked inside a vehicle) (3). When peripheral venous access is delayed or failed, central venous catheterization proves to be the traditional alternative. Nevertheless, obtaining a central venous access can require a lot of time and can lead to serious complications, including pneumothorax and accidental arterial catheterization (4). Ultrasounds is a non-invasive procedure, which allow the professional to view organs, tissues and blood flow images in real time, using high-frequency ultrasound waves (5).

For these reasons, the aid of ultrasounds for finding a peripheral venous access could be helpful in emergency/urgency, a tool already used by nurses for PICC (Peripherally Inserted Central Catheter) catheters positioning.

According to the latest European Resuscitation Council (ERC) and Advanced life support (ALS) guidelines of 2015, another option could be intraosseous access (I.O). Despite the suggestions in its use, I.O. access continues to be vastly underutilized (6).

Intraosseous access was first introduced in 1922, in the military field, during the Second World War and later progressively less used with venous catheter introduction (7). It is obtained by introducing a needle directly in the bone marrow cavity, highly vascularized. The robustness of the bone makes this cavity a non-collapsing system also in the presence of shock. For this purpose, specially designed devices are used with the availability of manual and semi-automatic equipment (6).

Additional routes of drug administration are also the sublingual, intranasal, endotracheal, subcutaneous and intramuscular pathway. Although, the latter are scarcely usable in emergencies/urgencies: only some drugs can be administered and it is impossible to infuse fluids or transfuse blood products (3).

Aim

The aim of the study is to examine what kind of vascular access is best for the drug delivery in emergency/urgency in international and national literature.

The research questions are the following:

- What are the most utilized administration pathways in emergency/urgency?
- What typology of medicines can be used throw these routes of administration?
- In what circumstances intraosseous access or ultrasound-guided peripheral venous access is used?
- What are the outcomes of intraosseous access and of ultrasound-guided peripheral venous access on the patient?

Method

The present literature review is focused on medicine administration pathways in emergency/urgency, through intraosseous access or ultrasound-guided peripheral venous access.

Literature review of scientific papers was conducted by developing a specific strategy for the main biomedical databases, of systematic review and Randomized control trials (RCT). The research strategy employed for documents retrieval involves the use of keywords/MESH terminology for each database combined.

The search for evidence was conducted by considering the publication time frame that is from January 2014 to November 2021. In the bibliographical research was included both primary sources (RCT) and secondary sources (literature systematic review, meta-analysis), without limiting the typology of sources. Consulted sources: bibliographic databases for primary or RCT studies (PubMed, Cinhal).

It was decided to consider the article relevant to the purpose of the research taking into account an adult population (older than 18 years old), without distinguishing gender, medical condition, surgical and

medical typology and hospitalization. Article used in the original language: Italian, English, French. The following keywords has been used in various combinations: Ultrasound-guided, peripheral venous catheter, peripheral venous access, vascular access devices, emergency, intraosseous, intraosseous vascular access, catheterization.

Results

The first study analyzed was a bibliographic review carried out by Aida Kordalli in 2015 in Italy, which showed that the positioning of a vascular access for the administration of drugs was one of the pivotal points of the patient's rescue. This is a priority that is applied both in intra- and inter-hospital area. ALS (Advanced Life Support) and ATLS (Advanced Trauma Life Support) guidelines stated that it was planned to find a venous access, in the C-Circulation phase. The most commonly used device was the peripheral venous catheter (CVP) (3).

A research conducted by Nicotera in 2014 in Italy, demonstrated that peripheral venous access allows the connection between the skin surface and a vein of the peripheral circle. There are various types of devices for peripheral administration of drugs including butterfly and cannula (short-stay catheters) and medium permanence catheters such as the Midline (2).

Another significant contribution in literature was given by the systematic review and meta-analysis carried out by Van Loon and colleagues (2018). From this study emerged that peripheral venous catheters (CVP), as well as drugs' administration, allowed the administration of liquids, nutrients and blood products. In the same survey conducted by Van Loon emerged that the traditional approach for an insertion of a peripheral venous access provided visual inspection and palpation of the extremities to locate a vein, followed by a needle puncture and by a catheter insertion (8).

A study conducted by Joseph D. and Tobias showed that many factors among them obesity, prolonged hospitalization and other co-morbidity conditions such as shock and dehydration could cause increased difficulties in finding a traditional peripheral venous access (9). Another survey led by Courtney and Jody in 2018 in USA (by interviewing 57 students) confirmed this thesis. They reiterated that if peripheral venous access could not be easily obtained, it could cause serious complications, including delays in diagnosis and medical treatment. Other disadvantages of the traditional peripheral venous access are the additional costs from the use of medical supplies, riskier vascular procedures with increased pain and suffering of the patient. Ultrasound guidance could be used to support traditional peripheral venous access for the positioning of a CVP (5).

The Da Ros, Ponzo and Kordalli's bibliographical research showed how the Centrally Inserted Central Catheter (CICC) proved to be a useful alternative for drugs' administration in emergency/urgency. Bibliographical research portrayed CICC device such as a biocompatible-material tube (third generation silicone or polyurethane) through which it is possible to access the nervous system.

The positioning of this device make possible the intermittent or continuous infusion of medications and/or drips, the administration of nutritional therapies, blood transfusions, etc. We can consider central a catheter whose tip was projected into the joint caval atrium, or at the lower third of the upper hollow seam (10). On the other hand, the CICC device needs experienced staff for its insertion and often X-ray control. This device has a high cost and procurement time, which is not different from that of a CVP, on the contrary, is usually higher. Even the complications are not negligible: venous thrombosis, artery injury, infection and pneumothorax (3).

Intraosseous access

An alternative to the CVP and the CICC devices is intraosseous access (I.O) which is usable in emergency/urgency. The last ALS and ERC guidelines of 2015 and evidences in literature recommend using the I.O. access early if finding a venous access is difficult or impossible. I.O. access is described in literature as a rapid and safe method and, even though there are evidences at international level, this is still a little-known and underused practice. Petitpas and colleagues' systematic review verified the points mentioned above, which explained that I.O. allowed resuscitation through liquids and high volume drugs with similar effectiveness to ve-

nous access. In adults, I.O. access was necessary, in case of emergency when accessing the peripheral veins was not easy to obtain. It can be used for the administration of medicine, for infusions and blood samples collection. The most frequent clinical situation, which require such type of vascular access, were situations that occurred during cardiopulmonary resuscitation for the administration of adrenaline and in the case of trauma for the ease in finding a vascular access (6).

An epidemiological investigation carried out by Zorgati in Italy, in 2015, provides a further contribution about bone anatomy. The essential part of the bone is the osteon: it has a cylindrical shape, which is composed of bone tissue and is crossed by a central canal, called Hivers, where there are a blood vessel and a nerve. Around the Havers Canal, the arrangement of bone tissue forms multiple lamellae, which together form the so-called "Havers System". Between the lamellae, spaces are formed called gaps, and within them small blood vessels radiate, which connect to the Havers System itself. This structure is present in the compact tissue, in which the vessels are well thickened. In the Havers canals, finally, we find some channels called Volkmann's that cross the bone from the bone marrow to the periosteum. The difference between these channels is the direction: the Havers channels run through the bones along their entire length, while the Volkmann channels make a transverse path to the bone. When drugs are infused into the medullary canal, they can reach the tissues thanks to the system just described. The infusion of drugs through intraosseous access is well protected by the compact tissue of the bone, as this prevents the compression or obstruction of the vessel. In addition, the study shows the existence of several devices able to ensure the placement of an intraosseous access. Regardless of the device used, removal should take place within 24 hours of insertion (11).

In an another review of the literature conducted by Bradburn and colleagues, were shown the major anatomical sites that allowed the finding of an intraosseous access. They were proximal tibia, distal tibia, distal femur, humeral and sternal (12).

As already mentioned, for the infusion of drugs is possible to use intraosseous access. Several studies has been carried out in this regard including the research of A. Kordalli. It holds primary significance from which it emerged that most of the drugs that were infused safely, through peripheral venous catheters, could also be infused safely through I.O pathway, except for chemotherapeutic (3).

In the study conducted by Anson in 2014, the bioequivalence of morphine administered intraosseously and intravenously in adult cancer patients is demonstrated. Each patient had both an intravenous and an intraosseous line and received 5 mg of morphine through one route, followed by 5 mg of morphine in the other route 24 hours later. No statistically significant differences were observed between intravenous and intraosseous pathways in calculated pharmacokinetic data, including peak concentration and maximum concentration time (7). Another study dealing with the pharmacokinetics of intraosseous drugs was the structured and retrospective review conducted by Clemency and colleagues, from November 2013 to April 2015. The study identified 1429 subjects who had received adrenaline during cardiac arrest. Adrenaline was administered venomously in 674 subjects (51.5%), while it was administered intraosseously in 636 subjects (48.6%). the study examined even if it had compared these two methods, had not highlighted any particular differences in the outcome of the ROSC at the time of arrival in the emergency room (13). Further confirmation to this thesis comes from a study conducted in 2015 in the United Kingdom by Bradburn and colleagues, which found that vasoactive medicinal products, which were usually administered through the central access, could be administered intraosseously; furthermore, cases where the contrast agent was administered successfully through the tibial seat were reported. In conclusion, the study stressed that I.O proved reliable for the administration of all anesthetic and resuscitation drugs. The study analyzed revealed a further clarification, namely that the infusion of drugs though I.O. device caused more pain than the insertion itself, since the insertion involved only a small cutaneous and bony site, while the active infusion caused intense pain. 2 % lidocaine was used to overcome this problem (12).

In Anson's review, USA, 2014, it was examined the existence of a possible role for intraosseous access. This review highlighted that I.O was a time-tested procedure which could fully be a part of patient care during the emergency, in crictical patients (7).

The systemic review of Petitpas and colleagues is a further confirmation of the thesis above. The review showed it took two decades before recommendations for I.O access were included in the guidelines of the American Heart Association of 2005, relating to the cases of cardiopulmonary resuscitation and emergency cardiovascular assistance for adults. The last guidelines published in 2015 showed that I.O access was to be located when venous access was not readily available (6). A study conducted in Italy in 2015 by Zorgati highlights the different circumstances where the insertion of intraosseous access (I.O) is an excellent alternative:

- cardiac arrest;
- severe hypovolemic shock with altered state of consciousness;
- need to infuse fluids or drugs without being able to find a venous access;
- unstable hemodynamics;
- severe respiratory failure;
- Glasgow Coma Scale score <8 (11).

The systemic review concluded by Petitpas gives a contribution in the literature aims to analyze intraosseous access outcomes and lists the main contraindications of intraosseous access:

– Infection at the insertion site (which was to lead to the choice of an alternative site to avoid the spread of sepsis or osteitis);
– A fractured bone led directly to the extravason of fluids and infused drugs and therefore ineffective;
– I.O access was not to be used in severe genetic or acquired diseases, osteogenesis imperfecta, osteoporosis and osteomyelitis.

The review highlighted that the contraindications are limited and compensated by the different sites of inclusion available (6). In addition to the contraindications for intraosseous finding, studies could derive the existence of post-placement complications as done in Zorgati's study:

- Needle displacement;
- needle obstruction after insertion;
- extravason of liquid;
- site infection;
- bone fractures (11).

Through observation of a population of 38 patients with an average age of 30 years, the prospective observational study of Chreiman and colleagues showed that intraosseous access attempts were as fast as peripheral venous access attempts, but with more than twice the probability of success. In addition, attempts to access the Centrally Inserted Central Catheter (CICC) in critical patients presented high failure rates with an estimated placement time of over 3 minutes. I.O access could not completely replace CVP or CICC, but it had to be considered as a front-line technique for critically traumatized patients (14).

Ecoguided peripheral venous

In the last few years, the use of the ultrasound in an interventional way, for finding a peripheral venous access, is proving to be a useful tool for nurses. The use of ultrasound and ultrasound imaging by nurses is not intended to make a medical diagnosis, but allows support for clinical and welfare maneuvers, allowing greater safety and reliability. For this reason, the positioning of ultrasound-guided peripheral venous catheters proves to be a valid choice in emergency-urgency. Research has shown that it is advisable to apply an ecoguided CVP in the following circumstances:

- Individuals with scarce venous patrimony, in which even the simple introduction of a needle-cannula may be difficult and force to try again the puncture;
- Patients where large volumes of fluids need to be infused quickly and where the cannula must have an adequate diameter (15).

In the study carried out by Courtney and Jones, interviewing 57 medical students, it was pointed out that the ultrasound could prove to be a valid aid for the positioning of an emergency-urgency peripheral venous access (5). The meta-analysis conducted by Van Loon and colleagues was also in favour of using the ultrasound. It described that the first ultrasound cannulation study of peripheral veins was a prospective study, conducted by Keyes and other colleagues in 1999, concluding that the eco-guided intravenous catheterization allowed to be more successful than the traditional technique (8).

Gottlieb and colleagues (2017) conducted a study with the aim of searching for existing data on the positioning of an eco-guided peripheral venous catheter, combined with suggestions to improve positioning. This study established the existence of different techniques for finding an ecoguided CVP. The most com-

monly used technique was the short-axis approach (e.g., transverse "out of plane"), where the vein was displayed in cross-section and the needle followed the path until it entered the vein. With this approach, it was essential that the transducer advance in synchrony with the tip of the needle.

The second most common technique was the long axis technique (e.g., "in plane"). Thanks to this technique, the entire length of the vein and needle was displayed. Before attaching the needle, it was necessary to make sure that the entire length of the vein was displayed. At the time the needle advanced, it was important that the needle and vein remained on the same plane. The benefit of this technique was that the entire needle was displayed, thus reducing the risk of wall injury. A third more recent technique is the 'oblique approach, considered by some the best method. This technique involves the view on the short axis with a rotation of the transducer of 45 degrees in an oblique angle to increase the area of the surface (and, consequently, the visualization) of the needle. The user benefits from the possibility of better visualization of the needle position compared to nearby structures, as well as improving the visualization of the needle.

Gottlieb's study (2017) suggested the "short axis approach" (out of plane) in order to be faster and easier than the long axis technique (in plane), as the latter may be associated with an increased risk of injury to the posterior vessel wall. While, with the oblique approach, even if considered the most effective, the finding by inexperienced personnel is more difficult. The results of the study by Gottlieb and colleagues also show that, regardless of the technique used, it was essential to avoid the compression of the veins during the attempt of positioning, because the veins were easily compressible and even slight pressure could collapse them. This can be avoided by using the palm of your hand or an extended finger to apply pressure and stop your hand in a more distant position. In addition, the study highlighted that the ultrasound machine must be placed on the counterside of the bed, allowing direct view by those who insert the peripheral access. Given the potential transmission of infections, it was important to use a sterile ultrasound gel or lubricant during positioning (16).

Different articles showed the perceived benefits of inserting peripheral, ultrasound-guided venous catheters. From the research carried out by Courtney and Jodi, it followed that the use of ultrasound created a more positive healthcare experience for patients, a reduction of delays in medical treatment, a better quality of care, greater autonomy for nurses (5). Furthermore, the review of Moore's literature revealed that ultrasound was a time-tested instrument; in fact, it allowed increasing success and decreasing complications in a wide variety of vascular access procedures. Ultrasound guidance could achieve success in difficult peripheral vascular access, potentially avoiding other more invasive procedures (17).

The cohort study carried out in Australia in 2017 and completed by Vanno Sou and colleagues demonstrated the effectiveness of the ecoguided cannulation, investigating a population of 379 patients. The study concluded that the use of the ultrasound guide for the insertion of the peripheral intravenous catheter by the health team in patients with difficult venous access was satisfactory; in fact, 9 out of 10 catheters were applied on the first attempt with significantly lower pain scores (18). In the research of Fuzier and colleagues, the percentages of finding peripheral venous access ecoguided, compared to the standard technique, were analyzed. It has been shown that, compared to traditional puncture, the use of ultrasound increased the success rate (97% vs. 33%) by requiring less time (13 minutes vs. 30 minutes), reducing the number of percutaneous perforations (1,7 vs. 3,7) and improving patient satisfaction (19).

Conclusions

The literature review revealed that the use of intraosseous access is a technique underused by health professionals, although easy to learn and simple to use in emergencies, presenting complications and limited contraindications (20).

From the various articles analyzed, the I.O proves to be perfectly comparable to venous access in terms of efficiency, but particularly advantageous when the latter is difficult to obtain and it is necessary to infuse liquids or drugs quickly and safely (3). The time taken to find a vascular access using intraosseous access, is equal to that taken in attempts of peripheral venous

access, and in addition, we have more than twice the probability of success (14). The I.O turns out to be indispensable in the treatment to the traumatized patient and, in particular, in the patient in cardiac arrest, considering the few minutes available to intervene beyond which important neurological consequences occur (11). Another advantage of intraosseous access is the ability to perform laboratory tests and determine blood type (21). Of course, I.O does not completely replace CVP or CICC, but it must be considered a key tool in life-threatening situations (14).

Given the approval and positive results of this technique, although it is still little known and widespread, we could act through awareness works in professionals illustrating the advantages and the techniques.

Articles about the use of the ultrasound, during the introduction of a peripheral venous catheter, show that ultrasounds are time-tested, able to reduce complications in a wide variety of vascular access procedures (17). Ultrasonic guided peripheral venous access is a simple technique with proven advantages (22). In circumstances where peripheral vascular areas are difficult to find, the ultrasound guide should be the first-line choice, excluding the traditional technique of palpation and direct visualization of peripheral veins (8).

Also for this technique, the establishment of an effective theoretical and practical program is essential for the training of experienced professionals in the use of ultrasounds, allowing a timely and optimal care to the patient (5).

From the analysis of the studies carried out it would appear that the two vascular access systems are both effective and safe. Intraosseous access, considering its high success rate, would be more suitable in critical patients, in imminent danger of life, where timely vascular access should be guaranteed if the finding of a CVP is not easily reachable. The peripheral and guided venous access, on the other hand, would be more appropriate in situations of urgency than that of emergency, since the first requires prompt but not as immediate interventions.

We believe that professionalism and knowledge are the cornerstone of our profession, therefore, encouraging the training of these two techniques would make it possible to be more effective in the administration of medicines and life-saving fluids in emergency and urgency, ensuring vascular access as quickly as possible.

Conflict of Interest: Each author declares that he or she has no commercial associations (e.g. consultancies, stock ownership, equity interest, patent/licensing arrangement etc.) that might pose a conflict of interest in connection with the submitted article.

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Author/ Year	Article Title	Type of investigation	State	Sampling	Any interventation	Conclusions
F.H. J. Van Loon, M. P. Buise, J. J. F. Claassen, A. T. M. Dierick- Van Daele, A. R. A. Bouwman (2018)	Comparison of ultrasound guidance with palpation and direct visualisation for peripheral vein cannulation in adult patients: a systematic review and meta-analysis	Systematic review and meta-analysis	Netherlands	1660 patients of whom 855 were included in the ultrasound guidance group and 805 patients in the traditional group (control) group..		This study demonstrates that ultrasound guidance leads to a higher success rate compared with the traditional technique of palpation and direct visualization of peripheral veins.
Kristen M. Chreiman, MSN, Ryan P. Dumas, MD, Mark J. Seamon, MD, Patrick K. Kim, MD, Patrick M. Reilly, MD, Lewis J. Kaplan, MD, Jason D. Christie, MD, and Daniel N. Holena, MD. (2018)	The intraosseous have it: A prospective observational study of vascular access success rates in patients in extremis	Prospective observational study	USA	38 patients with an average age of 30 years old		Vascular access attempts, using intraosseous (I.O) access, are as fast as peripheral venous access attempts, but have more than twice the probability of success. Attempts at central venous catheter access in patients in extremis, have high failure rates with an estimated placement time of more than three minutes. Therefore, I.O. access may not completely replace the peripheral venous catheter and central venous catheter, but should be considered as a first-line alternative for trauma patients in extremis.
Courtney Edwards, Jodi Jones. (2018)	Development and Implementation of an Ultrasound-Guided Peripheral Intravenous Catheter Program for Emergency Nurses	Observational study	USA	57 students	Interview	The establishment of an effective education program has led nurses to become proficient in ultrasound-guided peripheral venous catheter placement, providing optimal patient care. Emergency nurses recognize the benefits this program provides to their professional development skills and their ability to positively impact the healthcare environment.
Brian Clemency, Kaori Tanaka, Paul May, Johanna Innes, Sara Zagroba, Jacquelin Blaszak, David Hostler, Derek Cooney, Kevin McGee, Heather Lindstrom. (2017)	Intravenous vs intraosseous access and return of spontaneous circulation during out of hospital cardiac arrest	Structured and retrospective review	USA	1429 patients	Patient care records submitted electronically to the study group.	This study demonstrates that treatment with a first I.O approach is not inferior to a first E.V approach in patients receiving parenteral adrenaline for the treatment of out-of-hospital cardiac arrest. This represents some of the strongest evidence published to date in support of intraosseous vascular access in the treatment of cardiac arrest.

Author/ Year	Article Title	Type of investigation	State	Sampling	Any interventation	Conclusions
Gottlieb M, Sundaram T, Holladay D, Nakitende D. (2017)	Ultrasound-Guided Peripheral Intravenous Line Placemen: A Narrative Review of Evidence-based Best Practices	Literature Review	USA			This paper provides a review of existing data on the placement of an ultrasound-guided peripheral venous catheter, combined with suggestions for improving the placement and confirmation of such success.
Agata Dabrowska, Marek Dabrowski, Karol Bielski, Adrian Maciejewski, Emilia Surzyn. (2017)	Intraosseous access future, present and everyday life	Literature Review	Poland			From the article, it is highlighted that in recent years there have been several devices that have come to market providing quick and easy intraosseous access. For medical rescue teams, the I.O. is a fundamental tool to reduce the time required in the placement of a vascular access, to provide analgesic medications and life support medications. Another advantage of intraosseous access is the ability to test for blood gases and to determine blood type.
Vanno Sou, Craig McManus, Nicholas Mifflin, Steven A. Frost, Julie Ale and Evan Alexandrou. (2017)	A clinical pathway for the management of difficult venous access	Cohort study	Australia	379 patients		The health care team's use of ultrasound guidance for peripheral intravenous catheter insertion in patients with difficult venous access was satisfactory. 9 of 10 catheters were placed on the first attempt.
Régis Fuzier, Pierre Rougé, Sébastien Pierre. (2016)	Abords veineux périphériques échoguidés	Literature Review	France			Ultrasound is likely to be useful for difficult peripheral vascular areas. A period of training in ultrasound-guided venous puncture techniques is necessary.
F. Petitpas, J. Guenezan, T. Vendeuvre, M. Scepi, D. Oriot, O. Mimoz. (2016)	Use of intra-osseous access in adults: a systematic review	Systemic Review	France			The use of I.O. infusion, is increasing in adults, now an alternative for vascular access in emergency situations. In addition to the patient in cardiac arrest, I.O. access is usable for patients with trauma, shock, and, more globally, for any patient requiring emergency parenteral access. Contraindications are limited in number and offset by the various insertion sites available. The insertion technique can be easily learned with high success rates after a short training course. Thus, I.O. access is an indispensable tool in life-threatening situations.

Author/ Year	Article Title	Type of investigation	State	Sampling	Any interventation	Conclusions
Mohd Saif Khan, Vaibhav B. Sabnis, Dilip Shankar Phansalkar, Smiksha P. Prasad, Ali Hasan Faiz Karnam (2015)	Use of ultrasound in peripheral venous catheterization in adult emergency and critical care units	Literature Review	India			Ultrasound-guided peripheral venous access is a simple technique with proven advantages and therefore, should be routinely practiced in emergency and critical care situations by nurses, technicians, and physicians following appropriate training.
Linda Zorgati. (2015)	The use of intraosseous access: a survey among nurses of the suem 118 operating centers in Veneto	Observational study	Italy		Survey	Promoting theoretical and practical training in use of alternative techniques, such as intraosseous access, would be more effective in the timely administration of life-saving medications, with less risk of failure.
Aida Kordalli. (2015)	Intraosseous access: safety and efficacy in intra- and extra-hospital emergencie	Literature Review	Italy			The professional growth of healthcare professionals, technological development and clinical studies demonstrates the usefulness and effectiveness of the I.O. device. However, its use, especially in Italy, is limited.
Garside Joanne, Prescott Stephen and Shaw Susan. (2015)	Intraosseous vascular access in adults – a review of contemporary practice	Literature Review	United Kingdom			I.O. access is considered an alternative route of vascular access. Documented practices are established only in prehospital and specialty emergency department settings. Achieving insertion competency is relatively easy following minimal preparation, although ongoing maintenance of competency is less clear. Vascular access I.O. is associated with minimal complications, although pain is a significant problem for the conscious patient, especially during fluid administration.
Dr. Scott Bradburn, Dr. Stuart Gill, Dr. Matthew Doane. (2015)	Understanding and Establishing Intraosseous Access	Literature Review	United Kingdom			There are a variety of intraosseous devices on the market, providing a rapid, easy-to-use, and reliable route of administration for all anesthetic and resuscitative medications. I.O access is a short-term alternative to peripheral and central venous access, where some laboratory testing can be performed on an initial I.O aspirate. A comprehensive training and education program, with regular refresher sessions, should enable rapid and reliable placement of the I.O. device, with appropriate management and follow-up.

Author/ Year	Article Title	Type of investigation	State	Sampling	Any interventation	Conclusions
Joseph D. Tobias (2015)	Ultrasound-guided peripheral venous access: Is it the standard of care?	Literature Review	USA			Practice is needed to become proficient with ultrasound. Education is needed regarding the anatomy of deep vascular structures, cannulation techniques, and types of catheters available. While it cannot be said with certainty that the technology is the standard of care, it is certainly a useful adjunct to our current practice.
Warren James Cheung, MD, Hans Rosenberg, MD, and Christian Vaillancourt, MD, MSc. (2014)	Barriers and facilitators to intraosseous access in adult resuscitations when peripheral intravenous access is not achievable.	Observational study	Canada	205 doctors	Electronic survey	The data collected represent an important step in the action knowledge process by identifying specific factors associated with intraosseous access use. Potentially life-saving technique in patients requiring emergent vascular access.
Christopher L. Moore, MD. (2014)	Ultrasound First, Second, and Last for Vascular Access.	Literature Review	USA			Ultrasound is a proven tool that can increase success and decrease complications in a wide variety of vascular access procedures. Ultrasound guidance as a second-line approach can achieve success in difficult peripheral vascular access, potentially avoiding other more invasive procedures such as intraosseous access and central venous catheter placement.
Jonathan A. Anson, M.D. (2014)	Vascular Access in Resuscitation: Is There a Role for the Intraosseous Route?	Literature Review	USA			It is demonstrated that intraosseous vascular access can be achieved quickly and accurately in emergency situations. Given the efficiency of insertion and the few complications of this technique, there is clearly a role for intraosseous vascular access in the resuscitation of critically ill patients.