

This article was downloaded by:[UPEC - Prehospital Emergency Care]
[UPEC - Prehospital Emergency Care]

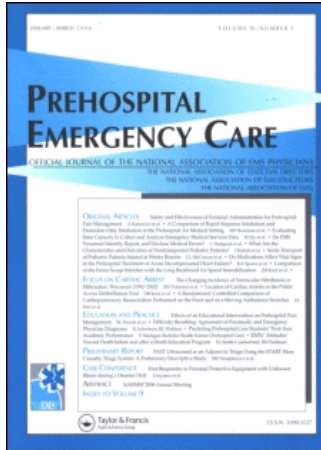
On: 22 January 2007

Access Details: [subscription number 768277147]

Publisher: Informa Healthcare

Informa Ltd Registered in England and Wales Registered Number: 1072954

Registered office: Mortimer House, 37-41 Mortimer Street, London W1T 3JH, UK



Prehospital Emergency Care

Publication details, including instructions for authors and subscription information:
<http://www.informaworld.com/smp/title-content=t713698281>

The Role of Intraosseous Vascular Access in the Out-of-Hospital Environment (Resource Document to NAEMSP Position Statement)

Raymond Fowler^a; John V. Gallagher^b; S. Marshal Isaacs^c; Eric Ossman^d; Paul Pepe^e; Marvin Wayne^f

^a Section on EMS, Disaster Medicine, and Homeland Security, Southwestern Medical Center, Dallas, Texas

^b Phoenix Fire Department EMS and Base Hospital, St. Luke's Medical Center, Phoenix, Arizona

^c Dallas Fire Rescue and Parkland Memorial Hospital, Dallas, Texas

^d Section of Prehospital and Disaster Medicine at Emory University School of Medicine, Atlanta, Georgia

^e Dallas Area BioTel System and, Emergency Medicine, Southwestern Medical

Center and Parkland Memorial Hospital, Dallas, Texas

^f EMS, Bellingham, Washington

To link to this article: DOI: 10.1080/10903120601021036

URL: <http://dx.doi.org/10.1080/10903120601021036>

Full terms and conditions of use: <http://www.informaworld.com/terms-and-conditions-of-access.pdf>

This article maybe used for research, teaching and private study purposes. Any substantial or systematic reproduction, re-distribution, re-selling, loan or sub-licensing, systematic supply or distribution in any form to anyone is expressly forbidden.

The publisher does not give any warranty express or implied or make any representation that the contents will be complete or accurate or up to date. The accuracy of any instructions, formulae and drug doses should be independently verified with primary sources. The publisher shall not be liable for any loss, actions, claims, proceedings, demand or costs or damages whatsoever or howsoever caused arising directly or indirectly in connection with or arising out of the use of this material.

© Taylor and Francis 2007

THE ROLE OF INTRAOSSEOUS VASCULAR ACCESS IN THE OUT-OF-HOSPITAL ENVIRONMENT (RESOURCE DOCUMENT TO NAEMSP POSITION STATEMENT)

Raymond Fowler, MD, John V. Gallagher, MD, S. Marshal Isaacs, MD, Eric Ossman, MD, Paul Pepe, MD, MPH, Marvin Wayne, MD

ABSTRACT

Thousands of critically ill emergency patients are treated in the out-of-hospital setting in the United States every year. In many patients intravenous (IV) therapy cannot be initiated because of inadequate access to peripheral veins. In some cases, this lack of vascular access may limit benefit of medications because of late administration.¹ Both speed and overall success of vascular access are important when evaluating potential methodologies for their use in the out-of-hospital environment. Insertion of an IV cannula has been reported to require substantial time in the prehospital environment, with a recent study reporting an average successful intravenous line placement time of 4.4 ± 2.8 minutes.² In critically ill pediatric patients, vascular access may present substantial difficulties to the provider.³ Intraosseous access may provide a significant time saving which may benefit many critically ill patients, both by decreasing the time to achieve access and by decreasing the time to administration of indicated medications.⁴ Achieving rapid administration of medications may facilitate the care of critically ill patients.¹ Devices are now available that permit rapid, accurate access to the intraosseous space. Recent changes in the American Heart Association's resuscitation guidelines state that the intraosseous route should be the first alternative to difficult or delayed intravenous access.⁵ With these considerations, the role of intraosseous vascular access in the out-of-hospital environment should be reemphasized.

PREHOSPITAL EMERGENCY CARE 2007;11:63-66

INTRODUCTION AND AVAILABLE METHODOLOGIES

Intraosseous (IO) vascular access has a long history, dating back as far as the 1920s, when Drinker and Lund

Received November 15, 2005, from the Section on EMS, Disaster Medicine, and Homeland Security, Southwestern Medical Center, Dallas, Texas (RF); Phoenix Fire Department EMS and Base Hospital, St. Luke's Medical Center, Phoenix, Arizona (JG); Dallas Fire Rescue and Parkland Memorial Hospital, Dallas, Texas (SMI); Section of Prehospital and Disaster Medicine at Emory University School of Medicine, Atlanta, Georgia (EQ); Dallas Area BioTel System and, Emergency Medicine, Southwestern Medical Center and Parkland Memorial Hospital, Dallas, Texas (PP); and EMS, Bellingham, Washington (MW).

Address correspondence to: Raymond L. Fowler, MD, FACEP, Associate Professor of Emergency Medicine, Southwestern Medical Center, 5323 Harry Hines Blvd., Suite E6.110, Dallas, TX 75390-8890. e-mail: rrray@doctorfowler.com

doi:10.1080/10903120601021036

described the sternum as a potential site for transfusions.⁶ Shortly afterward, Papper described access to the marrow space for the use of intravenous fluids.⁷ Further studies led to the intraosseous route being successfully used by military medical personnel during WWII to obtain vascular access in shock patients for whom IV cannulation was difficult or delayed.⁸

After World War II, the use of IO access rapidly declined. It was not until the 1980s that IO access made a significant reappearance in the noncombat clinical environment for the treatment of children.^{9,10} In 1988, based on significant experimental and clinical experience, IO access became a recommended standard therapy in the American Heart Association Pediatric Advanced Life Support (PALS) standards.¹¹

Current technologies for introducing intraosseous access use three distinct methodologies of needle placement—manual, impact-driven, and powered drill. Most of the manually inserted needles and impact-driven devices have been available for some time (Illinois Sternal Needle™ and Jamshidi™, Cardinal Health Care; Dieckmann™ from Cook Critical Care). These devices include hollow steel needles with removable trocars that prevent plugging of the needles with bone fragments during insertion. Estimated time for preparation and insertion varies from device to device.

One form of impact-driven device is designed solely for sternal access (FAST 1™ Intraosseous Infusion System, PYNG Medical Corporation, Richmond, BC, Canada). This device requires pressure to be applied to a series of stabilizing probes on a spring-loaded penetrating needle. Further pressure triggers the release of a hollow needle into the sternal medullary space. The needle design prevents the operator from accidentally penetrating through the sternum. Insertion is instantaneous upon releasing the spring, and intravenous tubing is preconnected to the implanted needle. Minimum training standards for its use in the prehospital arena have been described.¹² Estimated time for preparation and insertion is 50 seconds.¹³ Removal of the needle requires both a specific threaded tool provided with the device and appropriate training in the technique of removal.

A second impact-driven device (Bone Injection Gun, WaisMed Ltd, West Hempstead, New York) uses a spring-loaded injector mechanism to fire the IO needle into the medullary space of the tibia. Estimated time

for preparation and insertion is 17 seconds.¹³ As with the sternal IO device, investigators and practitioners using this injection gun have recommended careful stabilization of the device prior to and during insertion to prevent inappropriate placement. Moreover, a potential exists for operator or patient injury if the device is accidentally triggered or mistargeted.¹¹

A recently available drill-based device (EZ IO, VidaCare Corporation, San Antonio, TX) uses a handheld, battery-powered device to drill an IO needle at an appropriate depth into the intraosseous space. Insertion requires less than 10 seconds, and removal of the device is accomplished with a simple twisting motion.¹⁴

Although each device has strengths and limitations, all IO devices that are commercially available achieve rapid vascular access. Rates of ultimate success in attaining IO access vary among the devices, and no device is successful on every attempt. The Medical Director of an EMS agency should be involved in evaluating which device best fits the needs of patients, providers, and the budgetary considerations of the agencies.

SITES OF INSERTION

The site most often used for IO access in adults and children is the proximal tibia, just medial and inferior to the anterior tibial tuberosity. This area of the tibia has a large and richly vascularized medullary space as well as thinner and less dense cortical bone. Other insertion sites in adults include the sternum and humeral head. Site selection depends on the age and condition of the patient, the training and experience of the operator, and the FDA clearance status for the device(s). The proximal end of the tibia has been the site most widely studied and used in children.¹⁵ The distal tibia just proximal to the medial malleolus is a useful alternative site as well.

TRAINING

Aseptic technique is required for insertion of all intraosseous needles. For manual insertion devices, strength may be needed to drive the trocar through the cortex of the bone and into the marrow space. Furthermore, in both the manually inserted and impact-driven devices, training is important to ensure proper placement.¹⁶ For all IO devices, when insertion is performed in a conscious adult patient, administration of lidocaine is recommended during both insertion (subcutaneously prior to insertion) and into the marrow space prior to initiating the infusion.¹⁷

Training paramedics in the technique of intraosseous access has proven to be relatively easy.¹⁸ In most studies, a 1-hour lecture followed by 1 hour of hands-on experience has been considered sufficient training.¹⁹

SUCCESS RATES

Successfully achieving intraosseous vascular access is predicated upon the appropriate identification of

anatomical landmarks, the correct application of the device, and the absence of factors preventing the reaching of the marrow space, such as morbid obesity. One study examining EMT-B students using a sternal access device found that initial placement was as low as 55%, although 93% were ultimately successful.¹² A multicenter trial of the EZ IO device showed a 97% success rate of placement with fluid administration.¹⁴ Subsequent work by the same team found successful IO placement of 94% by EMT-B providers utilizing the IO drill, all on the first attempt.²⁰ Another pediatric critical care transport study noted a requirement of 1.2 intraosseous vascular attempts per patient, with a first attempt success rate of 78%.²¹ Finally, the wearing of chemical warfare protective garments by rescuers has been shown to increase the requirement for second attempts at intraosseous access with the bone injection gun.²²

CONSIDERATIONS, LIMITATIONS, AND CONTRAINDICATIONS

In most instances, when vascular access is indicated, intravenous access is the preferred route. However, if an intravenous line cannot be rapidly placed, or if the time required to place an intravenous line could compromise patient care, the intraosseous route should be considered. In certain patients, IO access may not be practical. For example, in obese patients the needles may not be long enough to reach the bone marrow space. Although combative patients may hinder vascular access, such patients may benefit from IO placement rather than IV access, because IO access requires less precise placement. The need for ongoing chest compressions may be a factor in determining the appropriate IO site. Patients with lower extremity trauma or amputations present further challenges and may require an alternative IO site.

General contraindications to IO placement include fractures at or above the chosen IO site, previous surgery involving the bone at the IO site, infection at the insertion site, and local vascular compromise.

Specific contraindications depend on the chosen IO site. Contraindications to sternal IO placement include previous sternotomy, suspected sternal fractures, and cardiac arrest with the need for chest compressions. The 2005 AHA guidelines for CPR emphasize the importance of uninterrupted chest compressions, and it is likely that compressions cannot be continued during placement of sternal IO access. Contraindications to extremity IO sites include suspected fractures at or above the chosen IO site on the affected extremity and previous orthopedic surgical procedures in the area of insertion (such as total knee replacement).

Achievable IO flow rates vary, depending on age and anatomy of the patient, insertion site, and use of a pressure pump. Flushing of the IO needle after insertion is recommended to improve flow rate.¹³ In general, the

volume of fluid given per unit time is similar to the rate infused through a 21-gauge catheter.⁴ A high pressure intraosseous infusion system has been previously described.²³

Pharmacokinetic studies have shown similar physiological effects and serum drug levels when comparing the intraosseous and intravenous routes.²⁴ Any currently approved medication or blood product that can be infused intravenously can be safely infused via the IO route. An exception to this may be the use of hypertonic saline (HS) for small volume resuscitation in hemorrhagic shock. Animal evidence has suggested potential harm to the affected extremity following use of HS in the tibial space.²⁵ This clinical scenario requires further study.

Very few complications have been reported in association with IO access.²⁶ In more than 4,200 cases of IO access in children, osteomyelitis occurred in only 0.6%, and usually only if the infusion continued for a prolonged period or if the patient had bacteremia at the time of insertion.³ In a prospective, 250-patient, multicenter study of the powered drill device, no observed cases of osteomyelitis, fat embolism, fracture, infection, extravasation, or compartment syndrome were found.¹⁴

Pain during both insertion and infusion under pressure has been cited as a concern. In one study, pain during IO infusion in conscious patients was measured on a modified Visual Analog Scale. The average pain was rated at 5 on a 1–10 severity scale.¹⁴ In another study using the drill device in 125 conscious patients, the average pain score recorded was 1.2 on a five-point scale, 1 being lowest and 5 being greatest.²⁷ The use of 1% lidocaine injected into the marrow space over 60 seconds has been shown to be effective in reducing pain during infusion.¹⁷

Cost is a key consideration for emergency medical services agencies in providing any element of patient care. Although IO vascular access devices tend to be more expensive than peripheral intravenous catheters, this additional cost must be weighed against two factors: (1) the potential clinical difference that successful line placement can make in both out-of-hospital and emergency department patients and (2) the saving of time to EMS agencies. Regardless, it is the responsibility of those providing out-of-hospital care to ensure that patients are transported in the best possible condition. As with all field treatment modalities, the economic impact must be weighed carefully during the agency budgeting process.

MEDICAL OVERSIGHT

Medical oversight must authorize the use of intraosseous vascular access devices in EMS systems and supervise their use through a quality review program. Indications for the use of intraosseous ac-

cess should be established in medical protocols for providers. Treatment protocols should be modified to indicate where the application of intraosseous access should be considered.²⁸ Employment of the devices by providers should be monitored, including their clinically appropriate use, the success of administration, and any reported complications including equipment malfunction.

CONCLUSIONS

IO access has been long accepted into the resuscitation armamentarium for children. Its documented historic success for adult use has now had validation in the recent history of resuscitative care. The advent of new devices increases the options available for vascular access through the IO route, particularly for adult patients.

With the considerations discussed herein, the authors of this article believe that EMS medical directors should examine the available technologies for IO access for all age groups, considering a technology that meets the tests of success rates, accuracy, speed, minimized errors and complications, and both patient and provider satisfaction.

References

- Rittenberger JC, Bost J, Menegazzi JJ. Time to give the first medication during resuscitation in out-of-hospital cardiac arrest. *Resuscitation* 2006;70(2):201–6.
- Minville V, Pianezza A, et al. Prehospital intravenous line placement assessment in the French emergency system: a prospective study. *Eur J Anaesthesiol* 2006;23(7):594–7.
- Rosetti VA, Thompson BM, Miller J, Mateer JR, Aprahamian C. Intraosseous infusion: an alternative route of pediatric intravascular access. *Ann Emerg Med* 1985;14(9):885–8.
- Miller L, Kramer GC, Bolleter S. Rescue access made easy. *JEMS* 2005 suppl, 8–18.
- Advanced cardiac life support guidelines. Management of cardiac arrest. *Circulation* 2005;112-IV, 57–66.
- Drinker CK, Drinker KR, Lund CC. The circulation in the mammalian bone marrow. *Am J Physiology* 1922;62:1–92.
- Papper ME. The bone marrow route for injecting fluids via the bone marrow. *Anesthesiology* 1942;3:307–13.
- Morrison, GM. The initial care of casualties. *Am Practitioner* 1946;1:183–4.
- Turkel, H. Intraosseous infusion. *Am J Dis Child* 1983;137(7):706.
- Orlowski JP. My kingdom for an intravenous line. *Am J Dis Child* 1984;138(9):803.
- American Heart Association and American Academy of Pediatrics: Textbook of pediatric advanced life support. American Heart Association 1988;43–44.
- Miller DD, Guimond G, Hostler DP, Platt T, Wange HE. Feasibility of sternal intraosseous access by emergency medical technician students. *Prehosp Emerg Care* 2005;9(1):73–8.
- Spriggs NM, White LJ, Martin SW, Brawley D, Chambers RM. Comparison of two intraosseous infusion techniques in an EMT training program. *Acad Emerg Med* 2000;7(10):1168.
- Davidoff J, Fowler R, Gordon D, Klein G, Kovar J, et al. Clinical evaluation of a novel intraosseous device for adults: prospective, 250-patient, multi-center trial. *JEMS* 2005;30(10):suppl 20–23.
- Driggers DA, Johnson R, Steiner JF, et al. Emergency resuscitation in children. The role of intraosseous infusion. *Postgrad Med* 1991;89(4):129–32.

16. Calkins MD, Fitzgerald G, Bentley TB, Burris D. Intraosseous infusion devices: a comparison for potential use in special operations. *J Trauma* 2000;48(6):1068-74.
17. Waisman M, Waisman D. Bone marrow infusion in adults. *J Trauma* 1997;(2):288-93.
18. Anderson TE, Arthur K, Kleinman M, Drawbaugh R, et al. Intraosseous infusion: success of a standardized regional training program for prehospital advanced life support providers. *Ann Emerg Med* 1994;23(1):52-5.
19. Dubick MA, Holcomb JB. A review of intraosseous vascular access: current status and military application. *Mil Med* 2000;165(7):552-9.
20. Guyette FX, Rittenberger JC, Platt T, et al. Feasibility of basic emergency medical technicians to perform selected advanced life support interventions. *Prehosp Emerg Care* 2006; 10(4):518-21.
21. Fiorito BA, Mirza F, Doran TM, Oberle AN, Cruz EC, Wendtland CL, Abd-Allah SA. Intraosseous access in the setting of pediatric critical care transport. *Pediatr Crit Care Med* 2005;6(1):50-3.
22. Ben-Abraham R, Gur I, Vater Y, Weinbroum AA. Intraosseous emergency access by physicians wearing full protective gear. *Acad Emerg Med* 2003;10(12):1407-10.
23. Feenstra WR, Henderson JM, Kramer GC. Design of an intraosseous infusion system. *Am J Emerg Med* 1994;12(4):477-84.
24. Orłowski JP, Porembka DO, Gallagher JM, et al. Comparison study of intraosseous, central intravenous, and peripheral intravenous infusions of emergency drugs. *Am J Dis Child* 1990;144(1): 112-7.
25. Alam H, Punzalan CM, Koustova E, et al. Hypertonic saline: intraosseous infusion causes myonecrosis in a dehydrated swine model of uncontrolled hemorrhagic shock. *J Trauma* 2002;52(1): 18-25.
26. (Manufacturer's database - VidaCare Corporation)
27. Gillum L, Kovar J. Powered intraosseous access in the out-of-hospital setting. *JEMS supp* 2005;24-26.
28. Pepe PE. Adult and Pediatric Protocol Principles. Dallas Area BioTel EMS Protocols 2006;pp. 7-11, www.biotel.ws.