Evaluation of Success Rate and Access Time for an Adult Sternal Intraosseous Device Deployed in the Prehospital Setting

Donald V. Byars, MD; Sara N. Tsuchitani, MD; Eleanor Erwin, MD; Bradley Anglemyer, MD; Jacob Eastman, MD

Department of Emergency Medicine, Eastern Virginia Medical School, Norfolk, Virginia USA

Correspondence:
Dr. Donald V. Byars
600 Gresham Drive
Raleigh Building, Suite 304
Norfolk, VA 23510 USA
Email: don.byars@gmail.com

Keywords: emergency medical service personnel; intraosseous infusion; prehospital care; resuscitation; sternum; vascular access

Abbreviations:
IO = intraosseous
IV = intravenous

Received: 24 February 2010
Accepted: 17 June 2010

Online publication: 3 May 2011

doi:10.1017/S1049023X11000057

Abstract

Introduction: Access to the vascular system of the critically ill or injured adult patient is essential for resuscitation. Whether due to trauma or disease, vascular collapse may delay or preclude even experienced medical providers from obtaining standard intravenous (IV) access. Access to the highly vascular intramedullary space of long bones provides a direct link to central circulation. The sternum is a thin bone easily identified by external landmarks that contains well-vascularized marrow. The intraosseous (IO) route rapidly and reliably delivers fluids, blood products, and medications. Resuscitation fluids administered by IV or IO achieve similar transit times to central circulation. The FAST-1 Intraosseous Infusion System is the first FDA-approved mechanical sternal IO device. The objectives of this study were to: (1) determine the success rate of FAST-1 sternal IO device deployment in the prehospital setting; (2) compare the time of successful sternal IO device placement to published data regarding time to IV access; and (3) describe immediate complications of sternal IO use.

Methods: All paramedics in the City of Portsmouth, Virginia were trained to correctly deploy the FAST-1 sternal IO device during a mandatory education session with the study investigators. The study subjects were critically ill or injured adult patients in cardiac arrest treated by paramedics during a one-year period. When a patient was identified as meeting study criteria, the paramedic initiated standard protocols; the FAST-1 sternal IO was substituted for the peripheral IV to establish vascular access. Time to deployment was measured and successful placement was defined as insertion of the needle, with subsequent aspiration and fluid flow without infiltration.

Results: Over the one-year period, paramedics attempted 41 FAST-1 insertions in the pre-hospital setting. Thirty (73%) of these were placed successfully. The mean time to successful placement was 67 seconds for 28 attempts; three of the 31 insertions did not have times recorded by the paramedic. Paramedics listed the problems with FAST-1 insertion, including: (1) difficulty with adhesive after device placement (3 events); (2) failure of needles to retract and operator had to pull the device out of the skin (2 events); and (3) slow flow (1 event). Emergency department physicians noted two events of minor bleeding around the site of device placement.

Conclusion: This is the first study to prospectively evaluate the prehospital use of the FAST-1 sternal IO as a first-line device to obtain vascular access in the critically ill or injured patient. The FAST-1 sternal IO device can be a valuable tool in the paramedic arsenal for the treatment of the critically ill or injured patient. The device may be of particular interest to specialty disaster teams that deploy in austere environments.

Byars DV, Tsuchitani SN, Erwin E, Anglemyer B, Eastman J: Evaluation of success rate and access time for an adult sternal intraosseous device deployed in the prehospital setting. ***Prehosp Disaster Med*** **2011;26(2):127–129.**

Introduction

Access to the vascular system of a critically ill or injured adult patient is essential for resuscitation. Whether due to trauma or disease, vascular collapse may delay or preclude even experienced medical providers from obtaining standard intravenous (IV) access. It is especially challenging to establish IV access in the prehospital setting due to limitations imposed on the paramedic by the condition of the scene. In addition, it is not feasible for paramedics to

obtain central venous access or perform peripheral venous cut-down if peripheral IV access cannot be established.

Drinker was the first to examine intraosseous (IO) infusion in 1922,[1] and today, IO infusion is a well-established alternative to IV infusion. The use of the tibial IO device is accepted widely in the pediatric population, and now is a standard part of the American Heart Association's *Pediatric Advanced Life Support* (PALS) textbook.

Access to the highly vascular intramedullary space of long bones provides a direct link to central circulation. The sternum is a thin bone identified easily by external landmarks that contains well-vascularized marrow. The IO route can deliver fluids, blood products, and medications rapidly and reliably. Certain resuscitation drugs attain comparable pharmacokinetic parameters whether administered IV or IO.[2] Resuscitation fluids administered by IV or IO achieve similar transit times into central circulation, as demonstrated by radionuclide tracer studies.[3] The FAST-1 Intraosseous Infusion System (Pyng Medical Corporation, Vancouver, Canada) is the first US Food and Drug Administration-approved mechanical sternal IO device. The objectives of this study were to: (1) determine the success rate of FAST-1 sternal IO device deployment in the prehospital setting; (2) compare the time of successful sternal IO device placement to published data regarding time to IV access; and (3) describe immediate complications of sternal IO use.

Methods

The Institutional Review Board at the Eastern Virginia Medical School approved this study and waived written informed consent by study participants.

Study Materials and Training

All paramedics in the City of Portsmouth, Virginia were trained to correctly deploy the FAST-1 sternal IO device during a mandatory education session with the study investigators. Education included a one-hour instructional video and a simulated FAST-1 deployment and removal to appreciate the pressure required to insert the device. The deployment technique followed the instructions in the device user's manual.[4] In addition, study investigators showed nurses at the two receiving emergency departments how to care for and remove the sternal IO.

Subjects and Device Deployment

The study subjects were critically ill or injured adult patients in cardiac arrest who were treated by paramedics during a one-year period. When a patient was identified as meeting study criteria, the paramedic initiated Advanced Cardiac Life Support (ACLS) or Advanced Trauma Life Support (ATLS) protocols; the FAST-1 sternal IO was substituted for the peripheral IV to establish vascular access. Time to deployment was measured with a stopwatch provided with study materials. Time started when the plastic bag containing the FAST-1 was opened, and time stopped at successful placement of the sternal IO. Successful placement was defined as insertion of the needle, with subsequent aspiration and fluid flow without infiltration.

Data Collection

After arrival at the emergency department, the paramedic and the attending emergency department physician completed data sheets regarding the deployment of the device.

Results

Over a one-year period, paramedics from the City of Portsmouth, Virginia attempted 41 FAST-1 insertions in the prehospital setting. Thirty (73%) of these were placed successfully. The mean time to successful placement was 67 seconds for 28 attempts; three of the 31 insertions did not have times recorded by the paramedic.

Paramedics listed problems with FAST-1 insertion, which included: (1) difficulty with adhesive after device placement (3 events); (2) failure of needles to retract and operator had to pull the device out of the skin (2 events); and (3) slow flow (1 event). Emergency department physicians noted two events of minor bleeding around the site of device placement.

Of the 11 unsuccessful attempts, seven failed because the FAST-1 did not deploy. There were two events of infiltration after placement, after which the FAST-1 was not used for patient resuscitation. One attempt resulted in inability to aspirate; this patient had a history of coronary artery bypass surgery. One attempt failed because although the needles were inserted, the catheter did not deploy.

Discussion

This is the first study to prospectively evaluate the prehospital use of the FAST-1 sternal IO as the first-line device to obtain vascular access in the critically ill or injured patient. Previous studies describing the prehospital use of the FAST-1 only have initiated FAST-1 deployment if one or more IV insertion attempts failed.[5–7] The paramedics in the current study achieved a one-year 73% success rate for sternal IO placement after one training session. This percentage is well within the range of published success rates of 72 to 84%.[5–7] It also has been shown that as providers become more experienced with the FAST-1, success rates improve.[7] The average time to obtain vascular access, 67 seconds, also was within previously reported times of 64 to 77 seconds.[5,7]

Past experience with critically ill or injured patients illustrates the difficulty experienced by providers at all levels with peripheral access. Rossetti *et al* reviewed 66 pediatric emergency department arrests at a children's hospital;[8] 24% of patients did not have IV access for ≥10 minutes, and 6% of patients never had a working IV established. The findings in the current study suggest that providing them with a simple and quick alternative to peripheral IV access can reduce valuable time spent by paramedics prior to emergency department arrival. This may result in improved patient outcomes, as successful resuscitation has been correlated with shorter total time spent in the prehospital setting.[9]

Conclusions

The FAST-1 sternal IO device can be a valuable tool in the paramedic arsenal for the treatment of the critically ill or injured patient. The device may be of particular interest to specialty disaster teams that deploy in austere environments. The benefit of the FAST-1 sternal IO device in such a setting is that there are no batteries or any other moving parts or pieces to get lost or be misplaced. It is a single self-contained unit that operates on simple push power. This would make this particular device much more desirable for teams that have large caches of equipment with low turnover, such as large disaster response teams and tactical paramedic teams. In the authors' case, the City of Portsmouth Police Department's Tactical Response Unit paramedics now carry this device as standard equipment after this trial.

References

1. Drinker CK, Drinker KR, Lund CC: The circulation of the mammalian bone marrow. *Am J Physiol* 1922;62:1–92.
2. Orlowski JP, Porembka DT, Gallagher JM, *et al*: Comparison study of intraosseous, central intravenous, and peripheral intravenous infusions of emergency drugs. *Am J Dis Child* 1990;140:112–117.
3. Cameron JL, Fontanarosa PB, Passalaqua AM: A comparative study of peripheral to central circulation delivery times between intraosseous and intravenous injection using radionuclide technique in normovolemic and hypovolemic canines. *J Emerg Med*: 1989;7:123–127.
4. Pyng Technologies Corporation. Available at http://www.fast1sternal.com/wp-content/uploads/2008/08/trainers-manual-fast1-pm-002h-08aug.pdf. Accessed 26 August 2008.
5. Horwood BT, Adams J, Tiffany BR, *et al*: Prehospital use of a sternal intraosseous infusion device. *Ann Emerg Med* 1999;34(4):s65–s66.
6. Frascone RJ, Jensen JP, Kaye K, *et al*: Consecutive field trials using two different intraosseous devices. *Prehosp Emerg Care* 2007;11(2):164–171.
7. Macnab A, Christenson J, Findlay J, *et al*: A new system for sternal intraosseous infusion in adults. *Prehosp Emerg Care* 2000;4(2):173-177.
8. Rossetti V, Thompson BM, Aprahamian C, *et al*: Difficulty and delay in intravascular access in pediatric arrests. *Ann Emerg Med* 1985;14(9):885–888.
9. McSwain GR, Garrison WB, Artz CP: Evaluation of resuscitation from cardiopulmonary arrest by paramedics. *Ann Emerg Med* 1980;9(7):341–345.