Air Medical Journal 38 (2019) 147–149

Contents lists available at ScienceDirect

Air Medical Journal

journal homepage: http://www.airmedicaljournal.com/

Original Research

Effect of Intravenous Versus Intraosseous Access in Prehospital Cardiac Arrest

Linh Nguyen, BA [1], Stephen Suarez, MS [2], Jessica Daniels, AS [2], Cristina Sanchez, BS [2], Kim Landry, MD [2], Colby Redfield, MD [1,2*]

[1] *Florida State University College of Medicine, Tallahassee, FL*
[2] *Leon County Emergency Medical Services, Tallahassee, FL*

A B S T R A C T

Objective: The prevailing standard of care in prehospital emergency medical services (EMS) is that either intravenous (IV) or intraosseous (IO) access is an acceptable route for obtaining vascular access and delivery of resuscitation medications and volume expanders in cardiac arrest patients. The aim of this study was to evaluate the effectiveness of IV access versus IO access in terms of return of spontaneous circulation (ROSC) for patients suffering from cardiac arrest.
Methods: A retrospective chart review examining cardiac arrest data with a single advanced life support EMS agency over a 4-year period was performed. Cardiac arrest patients were identified from a quality assurance database. Exclusion criteria included trauma arrest, pediatrics, pregnancy, and obvious signs of death.
Results: A total of 795 patients remained after applying the exclusion criteria. A total of 183 (45.1%) out of 406 cardiac arrest patients achieved ROSC who had an IV placed. A total of 389 cardiac arrest patients had an IO placed with ROSC in 100 (25.7%).
Conclusions: Higher ROSC rates were achieved with IV access versus IO access. Limitations include the small sample size, a single EMS agency, and the retrospective nature of the study. Future studies should further evaluate the effectiveness of IO versus IV access in cardiac arrest and other low perfusion states.

According to the American Heart Association (AHA) 2017 extrapolations, approximately 347,000 adults experience emergency medical service (EMS)-assessed out-of-hospital cardiac arrest annually.[1] The prevailing standard of care set forth by the AHA in their advanced cardiovascular life support guidelines mandates adequate chest compressions in conjunction with obtaining vascular access to administer resuscitation medications and volume expanders for patients in cardiac arrest.[2]

Initially, intraosseous (IO) vascular access was limited to pediatric cases. However, since the early 2000s, there has been a rise of IO placement as the sole route of access in patients presenting with cardiac arrest in the field because of the ease of usage.[3-5] Current guidelines have changed to allow for either intraosseous or intravenous (IV) methods of obtaining vascular access when attempting to resuscitate a patient in cardiac arrest, particularly in cases in which IV access is difficult to achieve. Of note, the updated recommendations by the AHA were made based on studies that did not involve human subjects.[6] The National Association of EMS Physicians prioritizes preference for IV but defines IO as a "well established . . . rapid method of providing fluids and medications to patients."[7]

Data regarding the comparative efficacies of IO versus IV in patients with low perfusion states or the rates of return of spontaneous circulation (ROSC) are scant. Studies have yielded conflicting conclusions when comparing patient outcomes with the mode of vascular access. A 2016 study by Clemency et al[8] showed that "IO first approach was non-inferior to an IV first approach," whereas a 2017 study showed a lower likelihood of ROSC with IO in contrast with IV treatment.[9] The lack of consensus regarding IO versus IV use, as well as the overall lack of data, indicates a need for further research in order to optimize the acute care of patients with cardiac arrest in the prehospital setting. The purpose of this retrospective cohort study was to analyze the management and outcomes of patients in Leon County who initially present with cardiac arrest in the prehospital setting with the primary objective of determining a correlation between the mode of vascular access with ROSC.

* Address for correspondence: *Colby Redfield, MD, 911 Easterwood Drive, Tallahassee, FL 32311.*
E-mail address: Colby.redfield@gmail.com (C. Redfield).

1067-991X/$36.00

https://doi.org/10.1016/j.amj.2019.02.005

Methods

Study Setting

This retrospective cohort study was granted expedited status and approved by the Florida State University Institutional Review Board.

Leon County Emergency Medical Services (LCEMS) agency is a single-county EMS agency covering a population of approximately 300,000 people with an average total call volume of 40,000 calls per year. The high call volume can be attributed to several factors including multiple universities, major government agencies, and interstate travel. The current cardiac arrest protocol for LCEMS allows for either IV or IO access to be placed at the discretion of the on-scene paramedic. Florida EMS regulations call for each EMS medical director to determine appropriate sites for vascular access as part of agency-specific protocols. LCEMS protocols allow for peripheral vascular access to be established at standard sites (hand, forearm, and antecubital fossa) as well as the external jugular vein. Insertion sites approved for IO access during the years examined by this study include the proximal tibia and the proximal humerus.

Study Design

The primary objective of this study was to evaluate the effectiveness of IV access versus IO access in terms of ROSC for patients suffering from cardiac arrest. The LCEMS cardiac arrest database was queried for all patients who were treated in the field for cardiac arrest over a 4-year period from 2013 to 2017. A report was generated and reviewed by the study team for all patients at least 18 years of age inclusive at the time of presentation with prehospital atraumatic cardiac arrest. Patients were excluded if they were under 18 years of age, were pregnant, had a trauma-related cardiac arrest, presented with signs of irreversible death (eg, lividity or rigor), or if the patient had a "do not resuscitate" order.

The primary variables were the initial access method attempted, the vascular access used, and ROSC. Secondary variables included patient age, patient sex, time to patient encounter, patient characteristics, event circumstances, and patient care procedures.

Rates of IO versus IV attempts were calculated. For patients who were documented to have received both IV and IO modes of access, the initial route of drug administration was treated as the intended mode of access.

The chi-square test and univariate *t* test were used in the statistical analysis of the data for comparison of patient demographics, event circumstances, and patient care procedures. Secondary analysis was performed on the first access attempted even if unsuccessful to evaluate as an intent-to-treat arm.

Results

From January 2013 to December 2017, a total of 1,283 patients were identified from the data set. Of these, 488 patients were excluded because of various combinations of trauma-related cardiac arrests, pediatric cases, dead on arrival, and/or incomplete data. Sixty-two of the excluded involved trauma, 40 were under the age of 18, and 419 were dead on arrival. Two patients were excluded because of incomplete data. Cases involving pregnancy were filtered at the time of data extraction and were not quantified or included in the original data set. After filtering out the cases according to the predetermined exclusion criteria and incomplete data, a total of 795 cases remained for analysis (Fig. 1).

There were no statistically significant differences between patients who received IO versus IV with regard to age, sex, elapsed time between receipt of the 911 call to EMS arrival on scene, initial cardiac rhythm (ie, shockable or nonshockable rhythm), or type of airway provided (Table 1).

A total of 183 (45.1%) out of 406 cardiac arrest patients achieved ROSC who had an IV placed. A total of 100 (25.7%) out of 389 cardiac arrest patients achieved ROSC who had an IO placed (Table 2). Intention-to-treat analysis reproduced similar statistical significance to the analysis of vascular access used. One hundred ninety-two out of 453 (42.4%) patients achieved ROSC when IV was attempted first compared with 91 who achieved ROSC out of 342 (26.6%) for whom IO was initially performed ($P < .001$, Table 3).

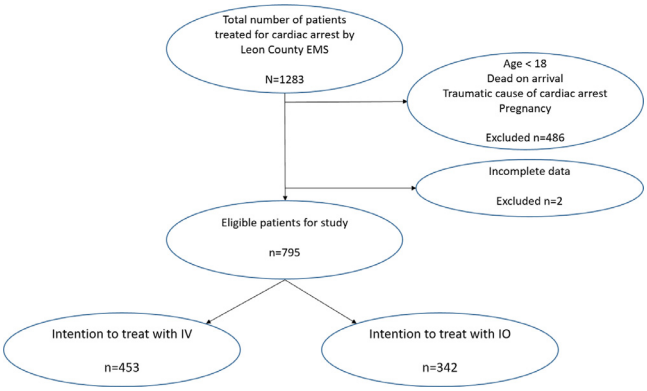

Figure 1. Study Flow Diagram

Discussion

When compared with IO, IV was associated with improved ROSC rates. Our study is consistent with a recent 2017 study that also compared IV versus IO in out-of-hospital cardiac arrest.[9] Upon looking at the initial attempts at vascular access, IV still had improved ROSC rates when compared with IO.

One theory for the difference in ROSC rates could be related to the low pressure state of cardiac arrest in terms of circulation. Prior studies have shown reduced rates of bone marrow blood flow in states of shock.[10] Blood flow should be further reduced in cardiac arrest with cardiopulmonary resuscitation. Multiple studies have shown reduced concentrations of drug in the bloodstream as well as increased transit time to the heart.[11,12]

A comparison of success rates and different locations of IO access was not conducted in this study because this variable was not routinely recorded in the LCEMS cardiac arrest database. Of those recorded, a majority selected the lower extremity for IO access because of the use of the LUCAS Automated Chest Compression

Table 1
Study Population Demographics

Characteristics	IV	IO	*P* Value
Age			.285
Mean	64.7	66.0	
Sex	IO	IV	.121
Male	292	202	
Female	161	140	
Initial rhythm			.113
Shockable	103	62	
Nonshockable	350	280	
EMS response time (seconds)	632	958	.191

EMS = emergency medical service; IO = intraosseous; IV = intravenous.

Table 2
Intraosseous (IO) Versus Intravenous (IV) Placement

	IV, n (%)	IO, n (%)	*P* Value
ROSC	183 (45.1)	100 (25.7)	<.001
No ROSC	223 (54.9)	289 (74.3)	

ROSC = return of spontaneous circulation.

Table 3
First Access Attempted: Intravenous (IV) Versus Intraosseous (IO)

	IV, n (%)	IO, n (%)	*P* Value
ROSC	192 (42.4)	91 (26.6)	<.001
No ROSC	261 (57.6)	251 (73.4)	

ROSC = return of spontaneous circulation.

System, Edmond, WA, which requires the upper extremities to be flexed upward and secured to the piston device. Tibial access was cited by paramedics as being preferred in these cases to minimize the risk of dislodgment associated with repositioning the arm to the LUCAS device. As of August 18, 2018, there are no published data on IO location and ROSC rates.

An important limitation of this study is a lack of documentation of motivation for providers with regard to their choice of vascular access or site. A justification for preference in vascular access is not routinely documented and is not well understood in the published literature; thus, it would be difficult to extract in this retrospective chart review. One possibility not evaluated by this study is that patients presenting with poor vascular access may have IO access attempted first. It may also be reasonable to conclude that, as a whole, patients with poor peripheral vascular access sites are generally in poorer overall health than those with easily accessed peripheral vascular sites. This should be evaluated more definitively in future studies.

An additional limitation of this study would be inaccurate or unknown lengths of time for which patients are in cardiac arrest; this variable may be unidentified because of various reasons (eg, patients going into unwitnessed cardiac arrests). These variables are beyond the scope of this proposed retrospective study but could be assessed in a follow-up randomized trial of IO versus IV in out-of-hospital cardiac arrest patients. Confounders such as time and distance from the scene to the hospital could also be accounted for in a future prospective follow-up study design. Variables regarding advanced airway management, such as the number of attempts, the duration of attempts, IV/IO access sites/locations, and rates of ventilation, could also be accounted for in the prospective study.

In this study, ROSC rates were higher than IV when IO access was used. A prospective randomized trial of IV versus IO in cardiac arrest is recommended to address the identified questions.

References

1. Benjamin EJ, Blaha MJ, Chiuve SE, et al. Heart disease and stroke statistics - 2017 update: a report from the American Heart Association. *Circulation*. 2017;135: e323–e337.
2. Link MS, Berkow LC, Kudenchuk PJ, et al. Part 7: adult advanced cardiovascular life support: 2015 American Heart Association guidelines update for cardiopulmonary resuscitation and emergency cardiovascular care. *Circulation*. 2015;132(suppl 2): S44–S64.
3. Lewis P, Wright C. Saving the critically injured trauma patient: a retrospective analysis of 1000 uses of intraosseous access. *Emerg Med J*. 2014;31:784.
4. Fuchs S, La Covey D, Paris P. A prehospital model of intraosseous infusions. *Ann Emerg Med*. 1991;20:371–374.
5. Fowler R, Gallagher JV, Isaacs SM, Ossman E, Pepe P, Wayne M. The role of intraosseous vascular access in the out-of-hospital environment (resource document to NAEMSP position statement). *Prehosp Emerg Care*. 2007;11:63–66.
6. Neumar RW, Otto CW, Link MS, et al. Part 8: adult advanced cardiovascular life support: 2010 American Heart Association guidelines for cardiopulmonary resuscitation and emergency cardiovascular care. *Circulation*. 2010;122(suppl 3): S729–S767.
7. O'Conor RE. Intraosseous vascular access in the out-of-hospital setting position statement of the National Association of EMS Physicians. *Prehosp Emerg Care*. 2007;11:63–66.
8. Clemency B, Tanaka K, May P, et al. Intravenous vs. intraosseous access and return of spontaneous circulation during out of hospital cardiac arrest. *Am J Emerg Med*. 2017;35:222–226.
9. Feinstein B, Stubbs B, Rea T, Kudenchuk P. Intraosseous compared to intravenous drug resuscitation in out-of-hospital cardiac arrest. *Resuscitation*. 2017;117:91–96.
10. Kawano T, Grunau B, Scheuermeyer FX, et al. Intraosseous vascular access is associated with lower survival and neurologic recovery among patients with out-of-hospital cardiac arrest. *Ann Emerg Med*. 2018;71:588–596.
11. Hoskins SL, do Nascimento P Jr, Lima RM, Espana-Tenorio JM, Kramer GC. Pharmacokinetics of intraosseous and central venous drug delivery during cardiopulmonary resuscitation. *Resuscitation*. 2012;83:107–112.
12. Zuercher M, Kern KB, Indik JH, et al. Epinephrine improves 24-hour survival in a swine model of prolonged ventricular fibrillation demonstrating that early intraosseous is superior to delayed intravenous administration. *Anesth Analg*. 2011;112:884–890.