



Original Contribution

Paramedics successfully perform humeral EZ-IO intraosseous access in adult out-of-hospital cardiac arrest patients[☆]

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Abstract

Objective: Studies on humeral placement of the EZ-IO (Vidacare, Shavano Park, TX, USA) have shown mixed results. We performed a study to determine the first-attempt success rate at humeral placement of the EZ-IO by paramedics among prehospital adult cardiac arrest patients.

Methods: A retrospective cohort analysis of data prospectively collected over a 9-month period. Data are a subset extracted from a prehospital cardiac arrest study. The cohort consisted of adult cardiac arrest patients in whom the EZ-IO placement was attempted in the humerus by paramedics. Choice of vascular access was at the discretion of the paramedic; options included tibial or humeral EZ-IO and intravenous. Primary outcome is the percentage of successful placements (stable, flow, without extravasation) on first attempt. Secondary outcomes are overall successful placement, complications, and reason for failure. Data were collected during a post-cardiac arrest interview.

Results: Humeral intraosseous (IO) access was attempted in 61% (n = 247) of 405 cardiac arrests evaluated with mean age of 63 (±16) years, 58% male. First-attempt successful placement was 91%. Successful placement was 94%, considering the second attempts. In the unsuccessful attempts, 2% reported obesity as the cause, 1% reported stable placement without flow, and 2% reported undocumented causes for failure. There were also 2% reports of successful placement with subsequent dislodgement.

Conclusions: The results of this study suggest a high degree of paramedic proficiency in establishment of IO access in the proximal humerus of the out-of-hospital cardiac arrest. Few complications suggest that proximal humeral IO access is a reliable method for vascular access in this patient population.

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1. Introduction

1.1. Background

Intraosseous (IO) access has been well established as an efficacious method of fluid and drug administration [1,2]. Recent advanced cardiac resuscitation recommendations have recognized the IO infusion as efficacious as intravenous cannulation for fluid and drug administration [1]. The noncollapsible nature and reliable portal to central venous pathways make IO an attractive first-line option in the prehospital patient in extremis. This is true particularly in the setting of cardiac arrest.

The Food and Drug Administration has approved IO access at the proximal humerus, proximal tibia, and the sternum for fluid and drug administration for the adult cardiac arrest. The humeral site is attractive because of a presumed shorter drug delivery time due to the proximity to the central circulation and higher fluid administration rates [3]. The humerus, however, may be more difficult to access than other sites.

1.2. Importance

During low perfusion states where delivery of fluid and/or medications may be time sensitive, humeral access may provide faster delivery to the central circulation. Several studies have documented high success rates and reduction of time-to-first-drug administration within the controlled environments of the laboratory and emergency department (ED) [3-7]. Limited data exist, however, regarding the success rates of proximal humerus IO placement by paramedics in the out-of-hospital environment.

1.3. Goals of this investigation

The objective of this project was to evaluate the success of paramedic IO placement in the proximal humerus in the adult out-of-hospital cardiac arrest (OHCA).

2. Methods

2.1. Study design

This is a report from a retrospective cohort analysis of prospectively collected data. The cohort consisted of patients that presented in cardiac arrest during a 9-month interval of a larger quality improvement project focused on improving outcomes from OHCA through the early and rapid administration of epinephrine. The University of Texas Health Science Center at San Antonio Institutional Review Board approved this study and made the determination that it is a component of a comprehensive quality improvement project.

2.2. Study settings and population

San Antonio, Texas, is the 7th largest city in the United States with approximately 1.4 million residents [8]. San Antonio Fire Department is (SAFD) the exclusive provider of 911 emergency medical services for the City. SAFD responds with a minimum of 2 paramedics per mobile intensive care unit ambulance, typically supported by Fire Division First Responders. Approximately half of the first responders have at least 1 paramedic with Advanced Life Support (ALS) capabilities. SAFD responds to approximately 125,000 medical calls per year with approximately 650 annual resuscitation attempts. The San Antonio area has 23 EDs receiving emergency medical service cardiac arrest patients. SAFD medical oversight and quality assurance and quality improvement is provided by the University of Texas Health Science Center at San Antonio, Department of Emergency Health Sciences, Office of the Medical Director by written medical protocol, and direct online medical consultation. All resuscitation attempts require a postevent debriefing with online medical control. Debriefing includes immediate quality assurance and quality improvement feedback and data collection.

2.3. Methods

All paramedics had prior experience with tibial IO insertion; each received 1.5 hours of didactic and hands-on instruction on humeral IO insertion. The didactic component included education on the indications, contraindications, landmark identification, insertion procedure, and demonstration. Didactics were followed by hands-on training including insertion into raw egg model and a simulated proximal humerus model (Sawbones, Vashon, WA). The training was conducted by faculty experienced in both prehospital medical education and IO access. At the conclusion of the training period, paramedics were evaluated on both cognitive understanding and insertion technique.

The resuscitation standing medical operating procedures for the SAFD indicated that humeral access was the preferred site for vascular access with no more than 1 attempt per bone, that is, a maximum of 2 humeral attempts could be made. Although the protocol indicated that the proximal humerus was the preferred access site, paramedics had the autonomy to opt for alternative sites as the situation dictated. Other sites available were tibial IO and intravenous access but were deemphasized if humeral was available. The treatment protocol directed that the preferred catheter length for humeral and tibial access was 45 and 25 mm, respectively. The treating paramedic maintained discretion as to catheter length. Once the humeral IO space was accessed, the affected arm was secured to the torso by whatever mechanical means were readily available, typically a strap.

In addition, a video was produced and available online for the paramedics to reference. This video highlighted the sequence of events expected for cardiac arrest management.

A mandatory postresuscitation debriefing with online medical control also provided immediate feedback on protocol compliance.

2.4. Data collection

Data were collected during the immediate postresuscitation time frame and stored in a database maintained by the Office of the Medical Director. Every resuscitation attempt undergoes a mandatory debriefing immediately after the final patient disposition. This debriefing involves an interview of the lead medic with a faculty nurse or paramedic from the Office of the Medical Director. Specific to this project, data collected included patient demographic data, insertion site, number of attempts, paramedic performing, time elapsed from arrival at patient side to successful placement, number of attempts required for successful placement, total volume infused, and complications.

2.5. Outcome measures

The primary end point for this project was first-attempt successful placement. Successful placement defined as stable placement of the cannula with the ability to administer medication and/or fluid without signs of extravasation. Secondary end points were successful placement after the second attempt and identification of complications resulting in failure.

2.6. Data analysis

Descriptive statistics were used to represent the percentage and SDs of reported parameters. Data analysis was accomplished using Microsoft Excel (Microsoft Corporation, Redmond, WA).

3. Results

During the study period (July 2009 to March 2010), 405 resuscitation attempts were initiated, with an average age of 63 (±16) years and 58% male (Table 1). Humeral access as the initial site was attempted in 61% (n = 247) of these

Table 1 Characteristics of patients observed during study period

	Other	Humeral	P
Resuscitation attempts	n = 161	n = 244	N/A
Average age	63 (±16)	63 (±17)	1.0
% male	58%	58%	1.0
% survival to hospital discharge	6.8%	5.4%	.51

N/A indicates not applicable.

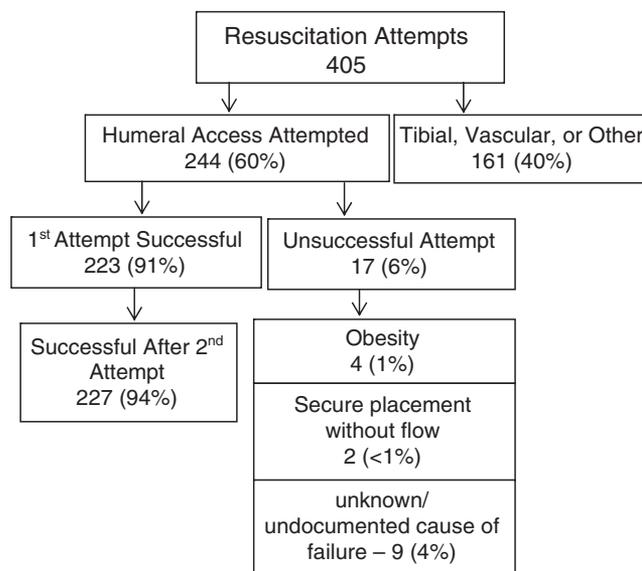


Fig. 1 Descriptive analysis of humeral IO success data.

cardiac arrests. First-attempt successful placement was 91% (n = 224). The secondary end point resulted in successful placement after second attempt of 94% (n = 232). See Fig. 1. Other sites were accessed in 40% (n = 161) of patients. Of cardiac arrest patients not receiving humeral IO access, 63% had intravascular or preexisting vascular access, and 38% had tibial placement. Success rates for the tibial subgroup were 95% and 98% for first and second attempt, respectively.

There was a 6% (n = 15) insertion failure rate in proximal humerus placement. Of this subgroup, there were 4 reports of obesity as the cause for nonsuccessful placement, 2 reports of stable placement without sufficient flow, and 9 were “other” or undocumented causes of failed attempts. There were also 4 reports (2%) of successful placement with subsequent dislodgement.

4. Discussion

Our study presents high success rates for proximal humeral IO placement by paramedics during cardiac arrest resuscitation with few complications. We observed 247 humeral attempts by paramedics with a 91% success rate on the first attempt. This was improved to 94% after the second attempt. Only 2% of all successful placements were reported to have dislodged during resuscitation efforts and/or transport to the ED.

Intraosseous infusion has been described as an adjunct to resuscitation since the early part of the 20th century [9,10]. The relative difficulty of establishing intravenous access in the child during emergency resuscitation and comparable success rates of IO placement led to the advocacy of IO placement by the American Academy of Pediatrics and the American Heart Association during the resuscitation of

pediatric patients [11,12]. Multiple highly vascular sites with minimal overlying soft tissue have been proposed for IO placement. To date, Food and Drug Administration clearance has been obtained for access of the proximal and distal tibia, proximal humerus, and the sternum [12].

The preponderance of early data regarding IO placement can be found in pediatric studies, with most IO placements performed manually. As a result of the aforementioned and as a result of familiarity, the most commonly advocated site in both children and adults has been the proximal tibia [12]. Powered IO devices allow for rapid IO access with minimal manual effort. It is also a skill easily taught to hospital and prehospital providers [13-15].

EZ-IO use on the proximal tibia has been studied in the civilian and military setting of trauma resuscitation [2,16], and proximal humeral placement has been analyzed in the emergency department laboratory [3]. In both environments, the power-assisted device was found to be effective in establishing rapid IO access in the adult. Ong et al [5] found that physicians in the ED had a remarkably high success rate in establishing both proximal humeral and tibial IO on the first attempt, 100% and 96%, respectively. The study of Ong et al was conducted using a convenience sample in the ED setting and directly compares tibial vs. humeral placement. Paxton et al [3] had similar placement success but showed a high occurrence of dislodgement. During this study, however, the investigator reevaluated the 25-mm catheter and began using the 45-mm catheter resulting in a significantly decreased dislodgment rate. Reads et al [17] reported poor paramedic success rates using the EZ-IO in both the proximal humerus and tibia during out-of-hospital resuscitation. This study observed only 30 proximal humeral and 58 tibial insertions with 60% and 90% first-time success, respectively. Reads et al also reported a disturbingly high rate of displacement, 33% in the humerus, throughout the study. It is unclear why the results from this study differ so remarkably from previously published reports, although small sample size and paramedics without previous IO experience may be contributing factors. In addition, we hypothesize that their high incidence of displacement is a result of the reported lack of a standardized securing method for either the arm or the IO catheter. The report of Paxton et al [3] clearly emphasizes the critical importance of securing the arm to prevent dislodgement.

Of the placement failures, obesity was noted as a factor in 4 of these patients. Although obesity has not been suggested to be a risk factor for humeral IO placement failure, the increased difficulty in landmark identification may increase the risk of failure. This risk must be recognized as a potential issue that may impede success. The obesity rate in our study population was not identified. The preference in the use of the 45-mm catheter for humeral cannulation may be a contributing factor to improved success rates as compared with Reads et al [17].

Preference for the proximal humerus is based on several factors, one being the proximity of the humerus to the central circulation. This proximity may provide shorter drug delivery time to the vital organs in the extremis patient as

compared with the tibia. This time saving may have importance for resuscitative drugs and for use in the initiation of therapeutic hypothermia. Iced saline infusion has been shown to be a very effective method for induction of therapeutic hypothermia in the postresuscitation care for cardiac arrest victims [18], and the high flow rates obtainable via the humeral IO access [3] make this an attractive method for iced saline delivery.

5. Limitations

This study is a subset analysis of a drug study, therefore, not specifically designed to compare the efficacy of proximal humeral vs proximal tibial or intravascular access.

The data presented here were collected during a post-cardiac arrest debriefing. The debriefing occurs immediately after the resuscitation encounter is complete, and data collection relied on self-reporting by the paramedics directly involved in the resuscitation. Data were not collected to identify the justification for tibial or intravenous at the initial site selection instead of humeral access.

This study also used 1 form of mechanical IO placement. Further studies will be needed to evaluate other devices for similar results.

6. Conclusion

In this retrospective study, paramedics successfully accessed the proximal humerus in 91% of initial IO attempts during resuscitation of the adult OHCA patient. Relatively, few complications suggest that humeral IO access is a reliable method of vascular access in this patient population. The proximal humerus should be considered a useful location for vascular access during prehospital cardiac resuscitation.

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