Intraosseous Access in Trauma by Air Medical Retrieval Teams

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Abstract

Trauma accounts for a significant portion of overall mortality globally. Hemorrhage is the second major cause of mortality in the prehospital environment. Air medical retrieval services throughout the world have been developed to help improve the outcomes of patients suffering from a broad range of medical conditions, including trauma. These services often utilize intraosseous (IO) devices as an alternative means for access of both medically ill and traumatically injured patients in austere environments. However, studies have suggested that IO access cannot reach acceptable rates for massive transfusion. We review the subject to find the answer of whether IO access should be performed by air medical teams in the prehospital setting, or would central venous (CVC) access be more appropriate? We decided to assess the literature for capacity of IO access to meet resuscitation requirements in the prehospital management of trauma. We also decided to compare the insertion and complication characteristics of IO and CVC access.

Trauma accounts for about 12% of all mortality globally and is the leading cause of death of young individuals under the age of 45 in Australia.[1,2] Hemorrhage is second only to severe central nervous system injury as a major cause of mortality in the prehospital environment where it accounts for 35% of all deaths.[3] The development of regional trauma systems has led to a decrease in overall mortality.[4,5] These systems are composed of physicians, nurses, and emergency medical services that organize to help bring trauma patients to appropriate centers of care and initiate treatment as early as possible. Retrieval services often play a significant role in caring for patients and initiating treatments in the prehospital environment, which leads to reduced mortality.[6-8] Some have suggested that this decrease is because of more aggressive treatment early on, such as advanced airway techniques and fluid resuscitation. One technique that has been used is intraosseous (IO) access for fluid and medication administration.

The IO route of access was first described in the first half of the 20th century and has been used mainly in pediatrics and military combat casualties for expedient vascular access.[9,10] Studies have been conducted to determine the usefulness, safety, feasibility, and administration of fluids and drugs in emergent resuscitation with IO access.[11-13] The use of IO access has been incorporated into pediatric advanced life support, advanced cardiac life support, and advanced trauma life support on the grounds of the evidence suggesting that it is quick, easy, and safe to use.[14-16] Air medical retrieval services throughout the world use IO devices as an alternative means for access of both medically ill and traumatically injured patients in austere environments in which conditions, both of the patient and the surrounding area, preclude successful peripheral intravenous (IV) access.[17,18]

Hemorrhagic shock differs from other forms of shock in that large amounts of volume replacement are needed in a relatively short period of time. Damage control resuscitation is a term given to the treatment approach to the traumatically injured patient with severe volume loss in which specific strategies for the replacement of blood and coagulation factors have been found to be beneficial in many studies.[19,20] Studies from the military literature have recommended a 1:1:1 transfusion protocol when initial fluid boluses do not improve hypotension.[21-23] This has led to the development of massive transfusion protocols for trauma patients with large-volume bleeds. Massive transfusion is generally defined as transfusion of more than 10 U blood within 24 hours at a rate of more than 150 mL/min.[24-26]

Varying rates of flow have been reported with IO access. Several studies have shown that flow rates of 125 mL/min cause washout and necrosis of the marrow and other complications.[27,28] Knowing that the IO access cannot reach acceptable rates for massive transfusion, should it be performed by air medical teams in the prehospital setting, or would central venous (CVC) access be more appropriate?

We decided to assess the literature for the capacity of IO access to meet resuscitation requirements in the prehospital

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Table 1. Reported Complication Frequencies of Central Venous Cannulation

Complication	Reported Frequencies (%)
Deep vein thrombosis	8.6-30[47,48]
Infection	5-8[47,49]
Hematoma	4.5[48]
Arterial puncture	3.5[49]
Pneumothorax	1-3[50,51]
Death caused by infection	1[49]
Air embolism	0.5[49]

management of trauma. We also decided to compare the known insertion and complication characteristics of IO and CVC access.

Scientific publications investigating the use of intraosseous access in trauma were identified using MEDLINE, PubMed, and EMBASE. Search terms included ("intraosseous" OR "IO") AND ("trauma" OR "penetrating trauma" OR "blunt trauma") AND ("pre-hospital" OR "aeromedical" OR "retrieval"). The search strategy was restricted to peer-reviewed studies published in English and after the year 1980 to present.

Meeting Resuscitation Requirements With IO Access

In trauma, around 6%-8% of patients develop hypotension. Of this 6%-8%, one third of the patients are hypotensive because of causes other than hemorrhage. Examples include pneumothorax, gastric dilatation, and drug ingestion. These patients will survive regardless of fluid administration if the underlying cause is correctly identified. Another third of the hypotensive trauma patients will die from nonsurvivable injuries, often before the arrival of a prehospital team. This leaves 2%-3% of all trauma patients who are hypotensive because of hemorrhage. It is this 2%-3% whose survival can be impacted by the resuscitation provided by the prehospital team.[29]

When assessing if IO access is suitable for the prehospital resuscitation of these patients, it is important to consider the choice of fluids and volumes that are likely to be used. Permissive hypotension and restricted resuscitation are terms used to describe the current consensus on the treatment strategies of trauma patients with uncontrolled hemorrhage. These strategies use small aliquots of crystalloid fluid to target suboptimal blood pressures or merely the presence of a pulse. The aim of these strategies is to prevent clot disruption, rebleeding, and coagulopathies.[22,23,30-33]

Ong et al[34] assessed the efficacy of 24 tibial and 11 humeral EZ-IO AD cannulas (15-G) inserted to deliver crystalloid resuscitation. The study used the EZ-IO battery-operated drill (Vidacare Corporation, Shavano Park, TX). A pressure bag infusion was able to achieve an average flow of 165 mL/min through the tibia and 153 mL/min through the humerus. These results have been reproduced elsewhere,[35] suggesting that IO access will provide sufficient flow rates for the restricted resuscitation of trauma patients in the prehospital setting.

In patients who require large volumes to maintain a palpable pulse, the infusion of blood products has been shown to be a viable option in air medical retrieval.[36] Sydney helicopter emergency medical services presented data on patients resuscitated with packed red cells over a 5-year period. They transfused 147 patients over this period; 94% were caused by blunt trauma. In 15%, IV access was found to be difficult, and IO access was used as an alternative. Forty percent of these patients received IO in 2 sites. On average, patients were resuscitated with 3 U packed red cells before arrival at the hospital (range, 1-6). No data were available comparing the volume of transfusion achieved in patients with IO and IV access.

The experience presented by Sydney hospital emergency medical services suggests that the use of blood products in prehospital air medical retrieval is viable and that IO access can be used as a quick rescue technique to transfuse blood. Multiple IO insertion sites and pressure bags will improve resuscitation flow rates.

Minimizing Scene Delays

Gaining early IV access enables the prehospital team to deliver analgesia and, if required, resuscitation fluids and medications. Despite the benefit of gaining early IV access, delaying transport because of repeated unsuccessful attempts could be detrimental. It has been shown that ambulance crews who cannulate spend more time on scene.[37] It is also known that time to hospital is an independent predictor of outcome in trauma.[38] A retrospective study by Demetriades et al[39] found worse outcomes in trauma patients brought to the hospital by paramedics compared with those brought in by bystanders, relatives, and the police. This has led to a consensus that when safe crews should cannulate en route to prevent on-scene delays.[40]

In prehospital air medical retrieval, the management of the trauma patient is complicated by the physiological stress of flight, length of transfer, and increased difficulty in gaining access en route. During times of failed peripheral IV access, air medical retrieval teams are commonly faced with the dilemma of a need for access and the impact of scene delays on survival.

Leidel et al[41] compared IO and CVC as an alternative for acute resuscitation when peripheral access was impossible. This small study found that IO insertion had a higher first pass success rate (90% vs. 60%) and was performed quicker (2.3 vs. 9.9 minutes). This study was based in the relatively controlled environment of the emergency department without confounding environmental factors that would make CVC insertion more difficult. However, the success rate and time to insertion for modern IO devices has been reproduced in prehospital reports.[42-44]