The Israeli Defense Force Experience With Intraosseous Access

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ABSTRACT Introduction: Obtaining vascular access is of paramount importance in trauma care. When peripheral venous access is indicated but cannot be obtained, the intraosseous route represents an alternative. The Bone Injection Gun (BIG) is the device used for intraosseous access by the Israeli Defense Force (IDF). The purpose of this study is to assess the success rate of intraosseous access using this device. Method: The IDF Trauma Registry from 1999 to 2012 was searched for patients for whom at least 1 attempt at intraosseous access was made. Results: 37 attempts at intraosseous access were identified in 30 patients. Overall success rate was 50%. No differences in success rates were identified between different care givers. Overall mortality was 87%. Conclusion: The use of BIG in the IDF was associated with a low success rate at obtaining intraosseous access. Although inability to achieve peripheral venous access can be considered an indicator for poor prognosis, the high mortality rate for patients treated with BIG can also stand for the provider's low confidence in using this tool, making its use a last resort. This study serves as an example to ongoing learning process that includes data collection, analysis, and improvement, constantly taking place in the IDF.

INTRODUCTION

Obtaining vascular access is of paramount importance in trauma care, allowing for a variety of interventions for the injured patient, from administration of medications to fluids and blood transfusion. A trivial procedure in the hospital settings, peripheral venous access can be vexing even for experienced prehospital care givers.[1] Several alternatives to intravenous access are being routinely used, and among them is the intraosseous route.

The intraosseous route is an alternative method for intravenous drug administration, fluid and blood resuscitation. Numerous resuscitation drugs and fluids have been reported to be administered using the intraosseous route including packed red blood cells.[2] Several devices were developed to provide access to the intraosseous space. The devices differ with respect to site of insertion, speed of insertion, and success rate.[3–5] The Bone Injection Gun (BIG; Waismed Ltd., West Hempstead, New York) is a second impact-driven device, which uses a spring-loaded injector mechanism to fire an intraosseous needle into the medullary space of the tibia.[6] In the Israeli Defense Force Medical Corps (IDF-MC), BIG is the only product available for intraosseous access.

IDF advance life support (ALS) providers are comprised of varying professions (physicians, paramedics–EMT-P) with varying level of training (regular vs. reserve service).[7] All ALS providers in the IDF are trained in BIG use. Training consists of a lecture and manual experience using chicken bones as a training modality. Advanced Life Support for Trauma recommendations include the use of an intraosseous access when venous access is not feasible because of circulatory collapse or following failure of two percutaneous peripheral venous catheterization attempts.[8] Accordingly, the IDF-MC venous access clinical practice guidelines (CPGs) instruct that an intraosseous device should be used in patients for whom two failed attempts (by an experienced provider) were made at peripheral venous access. Because of repeated reports concerning failure in achieving intraosseous access, we sought to assess IDF medical provider's success in obtaining intraosseous access using BIG in the prehospital setting.

METHODS

The IDF Trauma Registry is a prehospital military trauma registry containing data on trauma casualties (civilian or military) cared for by military medical teams. Data are gathered in the form of casualty cards. Casualty cards are followed by a more comprehensive after-action medical debriefing. Hospitalization data are collected directly from treating hospitals in the form of medical charts. All available information is being integrated to the IDF Trauma Registry at the Combat and Trauma Medicine Branch, at the surgeon general's headquarters.

A search through the registry from January 1999 to October 2012 was performed to identify all cases in which intraosseous access was attempted. Collected data included patients' demographics, type of injury, vital signs, lifesaving procedures, peripheral venous access attempts, intraosseous insertion site, number of attempts at intraosseous access, success of intraosseous access, drugs administered by the intraosseous route, identity of caregiver, and survival.

Data are presented as numbers and percentage (where appropriate), and statistical analysis for categorical data was performed using Fisher's exact test. Statistical significance was set at p values lower than 0.05.

This study was reviewed by the institutional review board of the IDF-MC and was approved for exempt status.

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RESULTS

Demographics

From January 1999 to October 2012, a total of 37 attempts at intraosseous access using BIG on 30 patients were identified. 16 patients (53%) were adults (ages range between 15 and 25), 3 (10%) were under the age of 5 years. In 10 patients (33%), age was not recorded. 29 casualties (97%) were males, with only 1 female. 15 of the patients (50%) were IDF soldiers, whereas 15 (50%) were civilians (Israelis and Palestinians).

Injuries

The mechanism of injury was penetrating in 24 patients (80%). Table I presents the mechanisms of injury and the main affected organs in the patient population.

Out of the 30 patients identified, 20 (66%) were found to be unconscious upon initial assessment, 6 (20%) were found to be conscious, and 4 (13%) had no documentation of consciousness status. 23 of the patients (77%) required mechanical ventilation.

Success Rate

Intraosseous access using BIG was achieved on the first attempt in 16cases (53%). Out of the 14 unsuccessful attempts, a second attempt was made in 5 cases (33%), out of which 2 (40%) were successful, a third attempt was made on one occasion and was not successful bringing the overall success rate to 18 (49%) out of 37 attempts. Data concerning previous attempts at obtaining an intravenous access were available for 18 (60%) of 30 patients. Four (22%) of these 18 patients had over than 2 attempts at intravenous access documented.

Medical provider's level of training was recorded for 25 (83%) of 30 patients. Paramedics were successful at obtaining IV access in 5 (50%) of 10 patients, whereas physicians were successful at obtaining IV access in 10 (67%) of 15 patients ($p = 0.75$).

TABLE I. Injury Characteristics

Mechanism of Injury	Number of Patients
Penetrating	25
GSW	15
Shrapnel	9
Stab	1
Blunt	5
Crush Injury	4
Fall	1
Injury Site	30
Chest	8
Head	7
Neck	4
Abdomen	3
Pelvis	2
Lower Extremities	2
Upper Extremity	1
Unknown	3

A focused intervention aimed at improving the success rate of BIG insertion was performed in 2011. We therefore assessed the success rate in the last 2 years of the study period, finding it to be 33% (successful in 2 out of 6 cases intraosseous access was attempted).

Four patients (13%) survived to hospital discharge. BIG insertion was successful in 2 (50%) out of 4 patients in the surviving group. In the nonsurviving group, BIG insertion was successful in 16 (64%) of 25 patients. Because of the small sample size, these differences did not reach statistical significance ($p = 0.62$).

DISCUSSION

BIG is the sole device that has been used by IDF ALS providers to obtain intraosseous access. Because of several reports on failure with the use of this device, we sought to perform a comprehensive evaluation of BIG use.

The reported success rate with the use of BIG varies greatly between different studies. In our study, the success rate using BIG was 53%. Although this success rate is similar to that reported by some authors, it is considerably lower that the success rate reported by others (80%, 55%, 59%, and 73%).[9–12] Failure of achieving medullary access using BIG has been reported to be caused by several factors; among them is device malfunction, technical errors, failure to remove the device's trocar, inability of the device to penetrate the bone cortex, and patient-related factors.[4,10,12,13] Data gathered from after-action reports indicate that in the current series, the most frequent cause for failure was related to the providers' skill, probably related to inappropriate identification of the insertion site. Therefore, in our view, the main downside of the device is the fact that it gives very little room for error and diversion from the recommended insertion site will result in unsuccessful insertion. This disadvantage of the device makes it nonsuitable for inexperienced medical providers who need to perform in an austere and stressful environment. Numerous factors likely contributed to the low success rate detected in our study. Unlike most medical care in civilian settings, treatment for combat trauma casualties involves different injury characteristics, may take place under threat, without proper lighting (or in complete darkness), while evacuating the casualty on uneven terrain. This study represents a mixed population including civilians in whom care was not always provided under fire, nevertheless, medical care for civilian casualties provided by military medical teams usually takes place in rural areas and under far-from-optimal conditions, including terror-related incidents. Another possible explanation lies in the difference in patients demographics, as the majority of the patients described in this study were male adults under the age of 25. This is unlike the findings of Schwartz et al[13] that reported an overall success rate of 91% in a group comprised mostly of older patients, with over 77% of the patients being over the age of 65 in whom a success rate of 87% was reported.[13] Young male patients have a denser bone cortex, thus making the penetration of the

intraosseous needle more likely to fail. Varying experience with BIG usage between the different ALS providers assessed at various studies also play a role. Being a rarely used device in the IDF, even the most skilled military care givers have little, if any, experience with its use.

The lower extremities were injured in 9 (30%) out of 30 patients. Success rates were higher for patients without lower extremity involvement than for those with lower extremity involvement (57% vs. 30%), however, because of the small sample size, this finding did not reach statistical significance ($p = 0.17$). As the tibia represents the preferable site for BIG insertion, this finding can be attributed to unavailable or deranged insertion site.

Our study demonstrated 87% mortality rate. Although not as prominent, other authors report high mortality in patients undergoing intraosseous access in the prehospital setting. Santos et al[2] reported a mortality rate of 62% in a study describing 58 patients who underwent intraosseous access using the EZ-IO device. Similarly, Schwartz et al[13] reported a mortality rate of 70%, a figure similar to that described by Hartholt et al.[12] These studies included both trauma and nontrauma patients. The high mortality rate in our study group as well as that reported by others suggests that the decision to attempt an intraosseous access is usually made for moribund patients. This finding is supported by the fact that 66% of patients were unconscious at the scene.

The IDF CPGs instruct that vascular access should be obtained during secondary survey and should not delay evacuation efforts. Providers are instructed to gain prehospital vascular access only for casualties who require resuscitation or when intravenous drug administration is required. IDF CPGs indicate the use of an intraosseous device in case of two failed attempts at peripheral venous access. However, current data suggest that in nearly a quarter of patients, over two attempts at IV access were made suggesting only partial adherence to these CPG.

Inability to obtain peripheral venous access can be considered a sign of lower intravascular volume and thus indicate a poor prognosis. However, the relatively high number of repetitive attempts to install a venous access before switching to using the device, combined with the high mortality rate among these casualties, can indicate that care givers in the IDF have low confidence in the device and use it only as a last resort, which in turn can be attributed to insufficient experience and the perceived invasiveness of the procedure.

Medical personnel caring for injured soldiers and civilians should be provided and trained with medical equipment for which they possess an acceptable level of confidence that ought to be obtained through appropriate training. Regardless of the underlying cause for the low success rate with the currently used BIG, being a salvage device for intravascular access, used to resuscitate severely wounded casualties, a 50% success rate is unacceptable. Because of the data indicating a low success rate with BIG use, the IDF-MC took several measures in an attempt to improve the current practice with BIG use. These measures included a revision of the training program, augmentation of specific simulator use, as well as repeated emphasis on learning how to use the BIG and continuous training to maintain competency. As these measures were taken throughout an extended time period, precise assessment of the contribution of these measures was problematic. However, as we could not detect any improvements in the success rate throughout the study period, it seems that these measures were not effective. Especially notable are the last 2 years of the study period, which included several report of failed attempts at intraosseous access, with an overall success rate of 33%, suggesting that other measures are required to make intraosseous access a feasible possibility.

Hubble et al[14] suggested that the procedure might be extended to use by intermediate-level care givers because of relatively straight-forward teaching and learning procedure process. Our results do not support this conclusion as the high failure rate reinforces our belief that BIG should only be used by highly trained providers.

The process described here is an example for ongoing data acquisition, analysis, implementation, and reassessment performed on regular basis by the IDF-MC. Constant re-evaluation of current practices will enable continued improvement in Combat Casualty Care thus help saving lives. As a result of gathered data and the current analysis, a decision was made to commence a search for a better alternative intraosseous device, as high-priority procurement project. Alongside a search for an alternative device, we have placed further emphasis on for vascular access during medical training in an attempt to improve adherence to current CPGs. Furthermore, specific focus is placed on alternative to intraosseous access including specific training aimed at accessing the external jugular veins as well as focused instruction on central venous access.

This study has several limitations. It is a small case series, limiting our ability to draw truly informed conclusion based on the available data. Data were collected retrospectively, resulting in incomplete data collection. The interventions performed in an attempt to improve BIG success rate were taken throughout an extended time period making an accurate assessment of its effect impossible. Several endpoints were subjective, potentially resulting in reporting biases. The study has been performed in a military environment and on a relatively young, predominately male population, which may not be representative of other trauma systems. A proper comparison between the current series and published data is problematic because of little available data and the variability between patients, providers, and scenarios. Finally, we have no data concerning the causes for failure at each intraosseous access attempt, significantly limiting our ability to perform an informed analysis of failed cases, as well as implement specific solutions in an attempt to address them.

CONCLUSION

Intraosseous access is a salvage procedure to be used when other measures to achieve venous access have failed. This study demonstrated a low success rate in the IDF of achieving intraosseous access. As this success rate is unacceptable for a salvage procedure, this finding prompts the IDF-MC to actively seek an alternative for the currently used device. The IDF-MC constantly engages in ongoing data acquisition and assessment of current practices. Evidence-based implementation of medical practices, training, and equipment will allow ongoing improvement of combat casualty care in our quest to provide optimal medical care for the injured patients in need.

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