

Application of Intra-Osseous Access in the Critical Care of Patients With Severe Multiple Trauma

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Abstract

Objective

This study aimed to evaluate the efficacy of intra-osseous (IO) access in the treatment of patients with severe multiple trauma.

Methods

This was a retrospective study in trauma center of the First Affiliated Hospital of Soochow University. The clinical data of 94 patients were reviewed in emergency room (ER) from April 2018 to September 2020. We summarized advantages of IO access for the following aspects: puncture efficiency, the duration of puncturing and success rate. Besides, we analyzed the relationship with central venous catheter (CVC), tracheal intubation and cardio-pulmonary resuscitation (CPR).

Results

The IO observation group presented a relatively good results in puncture efficiency (efficiency came into use within 15 minutes after being hospitalized: 36.17%), the duration of puncturing (less than or equal to 1 min: 93.62%), success rate (96.81%).

Conclusion

The application of IO in the treatment of patients can shorten the time and improve the success rate in rescuing critically ill patients. It serves as a parallel rescue method and is worthy of clinical promotion and skill acquisition.

Background

In the stage of rapid development of Chinese economic in the new era, the development of transportation, construction, industrial manufacturing had led to a sharp rise in traffic accidents and accidental injuries, and trauma had become a major social and public health problem. The presence of injury like road traffic injury could make the average life expectancy decrease by more than half a year. This not only caused great harm to families, but also cost the domestic GDP [1]. Generally, multiple injuries caused by traffic accidents and accidental injuries were serious, and the conditions developed rapidly, the incidence of shock was extremely high. The application of rapid infusion technology played a role of a golden bridge in the treatment of multiple trauma. Due to limited access to peripheral veins, whole-body intravenous administration may be impractical in emergency condition. The physicians can choose to insertion of central venous catheter, ultrasound-guided venous catheterization, or insertion of an intra-osseous device during initial fluid resuscitation. However, the procedures for IO access was simple and costed a short time, and had a higher success rate on first attempt. So it can provide fluid resuscitation for multiple trauma patients as soon as possible and improve patients survival outcome[2,3]. Hence, the purpose of this study was to evaluate the efficiency and the application of IO infusion technology, providing the

reality basis for improving the severe multiple trauma patients' survival rate, and promoting the skill acquisition.

Methods

Study design and population

This was a single-center, retrospective study in trauma center of the First Affiliated Hospital of Soochow University. The clinical data of 94 severe multiple trauma patients were reviewed in ER from April 2018 to September 2020. All patients accorded with diagnostic criteria for severe multiple trauma. The following inclusion criteria were applied: (1) Injury severity scores (ISS) ≥ 16 ; (2) Injured parts: according with the six parts of ISS [4]: head and neck: including scalp, brain, skull and cervical vertebra; face: including facial features and facial bones; chest: including chest organs, thoracic vertebra, diaphragm, thoracic cage, etc; abdomen: including abdominal cavity and pelvic organ, lumbar vertebra; body surface: including mechanical damage, burns, freezing and electrical damage caused by skin damage. Except the limbs. The injury involved at least two or more sites. (3) The time of admission after injury was less than 24 hours and the first diagnosis was made in our hospital. (4) No open or closed limb fractures. Exclusion criteria: (1) ISS < 16 ; (2) The patients were first treated in the external hospital and then transferred to our hospital. (3) Open or closed limb fractures; (4) Puncture site infection.

A total of 94 patients with severe multiple trauma received IO infusion were selected as eligible among 104 trauma patients, including 62 males and 32 females, with age ranging from 14 to 85 years (average 52.04 ± 17.93 years), ISS ≥ 16 . And we selected a semi-automatic IO device as a puncture device in this retrospective research.

Study protocols

All the hospitalized patients were triaged and immediately given electrocardiograph monitoring and urgent arterial blood gas. Furthermore, blood routine examination, biochemical examination, blood coagulation examination and other indicators were improved. Besides, we should record the time of patients entering the ER, the duration from being hospitalized to the beginning of placement into IO device, the puncture site, the duration of puncturing, the success rate, complications, and whether to insertion of CVC, tracheal intubation or CPR, to exploring the application effect of IO infusion technology. Besides, patient's data was anonymized and de-identified and the ethics committee of our hospital had approved it. This study conforms to the principles of the Declaration of Helsinki. (Audit number: (2020) approval No.243)

Results

Baseline characteristics of severe multiple trauma patients had shown in the table 1. There were two common insertion sites: proximal tibia (n=52) and proximal humerus (n=42). The average time came into use within 15 minutes after being hospitalized was 8.03 ± 4.43 min, presenting a relatively good results in

puncture efficiency (36.17%). The duration of puncturing (less than or equal to 1 minutes: 93.62%), success rate (96.81%) and complications (4.26%) (such as extravasation of fluid and transfusion obstacle). IO infusion won time for fluid resuscitation and free up space for tracheal intubation (n=53, 56.38%) and CPR (n=26, 27.66%), etc. It also allowed time for further insertion of CVC (n=40, 42.55%), serving as a transitional bridge. Among all the patients, 40 patients were catheterized in central venous, of which only 5 cases had established venous access prior to IO access and 1 case simultaneously with it. The rest were established after IO access.

Discussion

For the vast majority of shock patients with multiple trauma, a large amount of blood loss, decreased blood volume, and decreased tissue perfusion after the trauma can easily lead to metabolic acidosis, infection, and even multi-organ failure. In the case of fluid resuscitation, analgesia and antibiotics, the trauma patients need to establish a rapid circulatory pathway [5]. IO device was easy to operate, not affected by collapse of peripheral vascular, and can supply colloidal crystal, blood products, and drugs quickly and effectively. IO specimens can also be collected for blood types, biochemistry and blood gas analysis. Advantages highlighted in trauma patients with rapid infusion method, clinical treatment can be carried out by means of IO access.

Recognized, delay or unable to obtain venous channel was the major limitation of pre-hospital recovery [6]. Insufficient circulating blood volume and collapse of peripheral vascular can have difficulty in obtaining venous access. Establishing the central venous access was limited by technology and experience. In the case of failure to establish intravenous (IV) access within 90 seconds or 3 attempts, European Resuscitation Council (ERC) and the American Heart Association (AHA) both recommended IO placement as a drug supply route [7]. IO access was a real-life power drill equivalently, when the needle was inserted with this device, the operator drilled the needle with the power driver into the bone perpendicular to the insertion site. Through the research, IO access has simple operation steps, strong operability and high success rate, which is especially suitable for circulatory recovery in patients with multiple trauma caused by acute circulatory failure.

In addition, 56.38% of the patients underwent tracheal intubation and 27.66% implemented CPR in conjunction with IO infusion in a short period of time. There was no doubt that early professional airway management and proper oxygen supply can save lives [8]. First aid established advanced life support, all rescue measures must be efficient, fast and parallel. With intubation at the head and chest compressions, the establishment of rapid infusion access must avoid these areas, the lower limbs were good choice. IO access through proximal tibia was simple even in obese people. Meanwhile, the use of IO access should be limited to a few hours until IV access was achieved without exceeding 24 hours, it can effectively avoid infection and related complications [9]. 40 cases received CVC in this study, the duration from being hospitalized to the beginning of insertion of CVC less than or equal to 15 minutes accounted for 7.5%, which can be seen that IO access was a kind of transitional trauma recovery technology, only suitable for

the application of short time, especially suitable for emergency situations such as ER or intensive care unit.

The IO access served as an appropriate venous access site if access was needed in an emergency condition. Thus, many studies had detailed the statistical differences of pharmacokinetics in IV or IO route. In the study of Kashan University of Medical Sciences, IO access can rapidly deliver drugs into the main circulation, and there was no significant difference between the time taken for Methylene Blue (MB) to reach the central circulation via IO or IV routes [10]. In the study of IO xylazine administration, it demonstrated that systemic xylazine concentrations can be achieved comparatively to the IV route when the IO route was used [11]. Pharmacokinetics and pharmacodynamics of IO infusion technology had no difference in common infusion methods or even better.

Of course, a number of complications have been described with intra-osseous infusion. About 4.26% patients suffered short-term complications such as extravasation of fluid. Extravasation can cause severe compartment syndrome, we could not ignore this deadly threat particularly for those needing pressurized infusions, even the rate associated with IO access remained very low at 0.6% [12]. By removing the IO device, the continuous expansion and escalation of complications can be effectively avoided. For long-term complications, infection was more common, and the most serious complication was osteomyelitis. Thus, the only effective way to eliminate this complication was sterile operation. Second, the use of IO device should be removed as soon as possible.

Limitations

This study had certain limitations. First of all, we evaluated a relatively small number of patients with severe multiple trauma, which had slightly less representation. Second, the data from the trauma database were collected retrospectively, it may limit the generalizability of the conclusions. To address these limitations would require a large population to support our finding.

Conclusion

IO access had the advantages of simple operation, high efficiency and high success rate, but it was not widely used in emergency medical services of China. Although it only used as a temporary alternative to circulatory resuscitation, it was a key intervention in the resuscitation and treatment of severe multiple trauma patients in modern emergency medicine. Our emergency medical system should promote this special recovery development pattern, this was something we need to work on together.

Abbreviations

IO: Intra-Osseous

ER: Emergency Room

CVC: Central Venous Catheter

CPR: Cardio-Pulmonary Resuscitation

ISS: Injury Severity Scores

IV: Intravenous

ERC: European Resuscitation Council

AHA: American Heart Association

MB: Methylene Blue

Declarations

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Conflicts of interest

Authors have no financial or other conflicts of interest related to this submission.

Availability of data and material

Available upon request.

Authors' contributions

All authors have contributed to, read and approved the final manuscript for submission.

Ethics approval and consent to participate

Patient's data was anonymized and de-identified and reviewed by the Ethics Committee of our hospital. This study conformed to the principles of the Declaration of Helsinki. All authors have given consent to participate.

Consent for publication

All authors have given consent to publication.

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Tables

Table 1. Baseline characteristics of severe multiple trauma patients

		Number of cases	Percentage(%)
Sex	Male	62	65.96
	Female	32	34.04
Age (year)	<50	40	42.55
	50~	16	17.02
	60~	21	22.34
	70~	17	18.09
The puncture site	Proximal tibia	52	55.32
	Proximal humerus	42	44.68
The duration from being hospitalized to the beginning of insertion of IO device (min)	≤15	34	36.17
	(15-30]	26	27.66
	(30-45]	9	9.57
	(45-60]	7	7.45
The duration of puncturing (min)	>60	18	19.15
	≤1	88	93.62
Successful or not	(1-3]	1	1.06
	>3	5	5.32
Complications	YES	91	96.81
	NO	3	3.19
The duration from being hospitalized to the beginning of insertion of CVC (min)	YES	4	4.26
	NO	90	95.74
	≤15	3	7.50
	(15-30]	11	27.50
Insertion of CVC	(30-45]	9	22.50
	(45-60]	3	7.50
Tracheal intubation	>60	14	35.00
	YES	40	42.55
Cardio-pulmonary resuscitation	NO	54	57.45
	YES	53	56.38

	NO	41	43.62
	YES	26	27.66
	NO	68	72.34

IO, intra-osseous; CVC, central venous catheter.