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Assessment of Circulatory Management in Pediatric Polytrauma According to International Guidelines in Suez Canal University Hospital

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ABSTRACT

Background: Among kids older than a year old, trauma is the primary cause of illness and death. Injuries to two or more organ systems that could prove fatal or disabling are unfortunately not out of the ordinary in pediatric patients who have sustained multiple severe injuries.

Objective: To improve the circulatory management in pediatric polytrauma by detection of pitfalls according to international guidelines in Suez Canal University Hospital.

Patients and Methods: All children with polytrauma who were brought to the Emergency Department (ED) at Suez Canal University Hospital were included in a cross-sectional study. Patients were evaluated and cared for with an emphasis on circulatory management in accordance with Advanced Trauma Life Support (ATLS) standards. Next, the patient's outcome was documented.

Results: Obstruction of the airway, breathing difficulties, bradycardia, and extended capillary refill were substantially linked with the 9.5% death rate among pediatric polytrauma patients who presented to ED at Suez Canal University Hospital. Survival of the studied patients was statistically significant associated with higher frequency of performing chest X-ray ($p < 0.001$), pelvis X-ray ($p < 0.012$) and Focused Assessment with Sonography for Trauma (FAST) study ($p=0.024$).

Conclusion: Adherence to the international guidelines in evaluation and management of pediatric polytrauma patients is a cornerstone in improving outcomes and decreasing mortality.

Keywords: Pediatrics, Polytrauma, Circulatory management.

INTRODUCTION

The worldwide burden of disease is mostly attributable to injuries. Injuries to children account for a greater proportion of childhood deaths than all of the world's leading infectious diseases put together, making this a critical issue in public health. In children older than one year old, trauma is the leading cause of death and illness[(1)].

It's not unusual for paediatric patients with multiple severe injuries to present with damage to two or more organ systems, including those responsible for breathing, circulation, and digestion[(2)].

The global rate of child fatalities due to automobile accidents is 10.7 per 100,000. In contrast, the rate is 7.4 per 100,000 people in South and Southeast Asia and 19.9 per 100,000 people in Africa. Although deaths from traffic accidents are less common in Europe, they still account for about 20% of all injury-related deaths among EU children[(3)].

In 2004, 424 thousand persons of all ages died from falls around the world, according to the World Health Organization (WHO) Global Burden of Disease research. Although adults were more likely to die from a fall, children aged 5 to 9 had it as the eleventh greatest cause of mortality[(4)].

Almost half of all child abuse fatalities in 2018 involved children younger than one year old, and roughly 16 percent of abused children experienced more than one form of maltreatment[(5,6)].

Between 25 and 52 percent of all pediatric injury evaluations in Emergency Departments (ED) worldwide are due to falls. It is the severity of the traumatic brain injury that plays the most important role in determining the outcome of up to 27% of pediatric patients with multiple traumatic injuries[(7)].

Blood pressure in children can be maintained even after a massive and sudden loss of blood, which is not the case for adults (from 25 to 30 percent). Cardio-respiratory failure can manifest itself subtly, therefore it's important to keep an eye out for subtle changes in vital signs like heart rate, arterial pressure, and peripheral perfusion[(8)].

Last but not least, youngsters have a hard time adjusting to new environments, which makes determining their health even more challenging [(9)].

Children's systolic blood pressure may drop, but only after a reduction in blood volume of up to 30 percent. For doctors unfamiliar with the subtle physiologic changes children in hypovolemic shock exhibit, this could be deceptive. The only reliable indicators of hypovolemia and the need for prompt fluid resuscitation are a rapid heart rate and a lack of perfusion to the skin[(10)].

Up to our knowlage no such study was done to assess the Circulatory Management of pediatric polytrauma patients in our hospital.

AIM OF THE STUDY

To assess and treat pediatric patients who have been harmed by polytrauma and so to improving the circulatory management by detection of pitfalls

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according to international guidelines in Suez Canal University Hospital.

We choose the Advanced Trauma Life Support (ATLS) as it provides doctors with a simple, easy-to-remember framework. In addition, the application unifies the language used by medical professionals while treating individuals who have been injured.

PATIENTS AND METHODS

Eighty-four patients with pediatric polytrauma who presented to the Emergency Department at Suez Canal University Hospital.

They were evaluated and cared for in accordance with the gold standard in trauma care, the Advanced Trauma Life Support (ATLS) guidelines.

We focused on circulatory management starting from assessment by examination and investigation then treatment by fluid replacement and medications or surgical intervention if needed. This was monitored through filling out a questionnaire by the researcher.

After stabilizing the patient, the following was studied:

Primary assessment began with a thorough examination of the patient's airway, breathing, and circulation (A B C), followed by emergency care for any underlying causes of distress.

A. Air way:

Checking the patient's airway and maintaining a neutral neck position while doing so.

When an Airway is blocked, we must take into account:

- Jaw thrust.
- Suction may be necessary in the event of bleeding or secretions.
- Oropharyngeal, nasopharyngeal, as well as endotracheal intubation for airway according to case.

B. Breathing:

Clinical observation to evaluate breathing adequacy and airway patency. If you're having trouble breathing, keep these in mind:

- Mechanical ventilation.
- Restraining of the flailing chest from the outside.
- Managing tension pneumothorax by needle thoracotomy.
- Managing pericardial tamponade via pericardiocentesis.

C. Circulation:

Repeatedly evaluating the patient's oxygen levels, airway, and breathing to evaluate circulation:

- Pulse (Central as well as peripheral).
- Distal pulsation.
- Blood pressure.
- Capillary refilling time.

To think about if insufficient:

- Hold the bleeding of external source.
- Create 2 wide-bore IV lines (14 or 16 G).
- Urethral catheter.
- Donate blood and fluids if necessary.

D. Disability:

Checking Random Blood Sugar (RBS) and the Glasgow Coma Score (GCS) on non-diabetic patients to evaluate their neurological status.

E. Exposure:

Check the patient's body for signs of trauma. Spinally injured patient immobilized.

It is recommended that all polytraumatized patients undergo the following radiological procedures as a part of the primary survey:

- Focused Assessment Sonographic for Trauma (FAST).
- Pelvis X-Ray.
- Chest X-Ray (CXR).

The next step after accomplishing airway, breathing, and circulation is to take a thorough patient history and conduct a secondary survey. In this step, we collect information about each patient such as his/her age, gender, occupation, type of injury, time of injury, time of arrival, and time of resuscitation.

Fate at Emergency Department (ED): Each patient's outcome was documented, no matter what happened to them:

1- Underwent a surgical procedure.
2- Patient admitted to ward for observation.
3- ICU admission for a child.
4- Transferred.
5- Released from ED.
6- Tragic death in the Emergency Room (ER).

Ethical consent:

An approval of the study was obtained from Suez Canal University Academic and Ethical Committee. Every patient's guardian signed an informed written consent for acceptance of participation in the study. This work has been carried out in accordance with The Code of Ethics of the World Medical Association; Declaration of Helsinki for studies involving humans.

Statistical analysis

The collected data were coded, processed and analyzed using the SPSS (Statistical Package for Social Sciences) version 22 for Windows® (IBM SPSS Inc, Chicago, IL, USA). Data were tested for normal distribution using the Shapiro Walk test. Qualitative data were represented as frequencies and relative percentages. Chi square test ($\chi 2$) to calculate difference between two or more groups of qualitative variables. Quantitative data were expressed as mean ± SD (Standard deviation). Independent samples t-test was used to compare between two independent groups of

normally distributed variables (parametric data). P value < 0.05 was considered significant.

RESULTS

This study was a cross-sectional analysis of 84 pediatric polytrauma patients who presented to the Emergency Department (ED) at Suez Canal University Hospital and met our inclusion criteria. This study aims at assessing the Circulatory Management of pediatric polytrauma according to International guidelines at Suez Canal University Hospital.

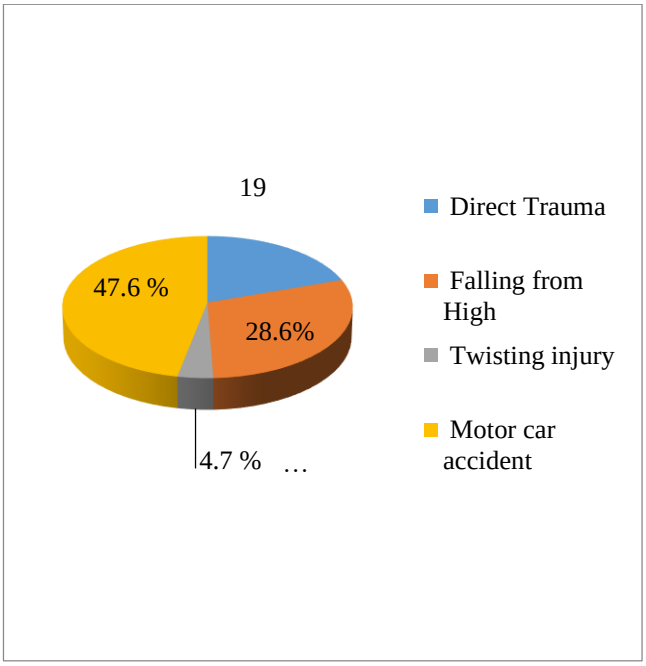

Figure (1): Mechanism of trauma among the studied patients

Figure **1** shows that the most prevalent mechanism of trauma was motor car accident (47.6%) and falling from height (28.6%) then direct trauma (19%).

Table **1** showed clinical characteristics of the studied patients. About 25% of the airway of the patients were at risk while, 32.1% of the patients needed assisted breathing. On assessing Circulatory Management of pediatric polytrauma, it was found that all patients had their pulse rate assessed while 42.6% of the patients had not their blood pressure or capillary refill assessed. Moreover, 61.9 % of the patients did not have their urine output measure.

Table (1): Clinical characteristics of the studied patients

Variables	n= 84
Airway, n (%)	
Patent	63 (75)
At risk	21 (25)
Airway adjuncts	5 (6)
Endotracheal intubation	16 (19)
Breathing, n (%)	
Self-breathing	57 (67.9)
Assisted breathing	27 (32.1)
Pulse	
Not done	**0 (0)**
Done	**84 (100)**
Tachycardia	49 (58.3)
Normal range	18 (21.4)
Bradycardia	17 (20.2)
Blood pressure	
Not done	**36 (42.6)**
Done	**48 (57.4)**
Normal range	28 (33.3)
Hypotensive	20 (23.8)
Capillary refill	
Not done	**36 (42.6)**
Done	**48 (57.4)**
Normal	25 (29.8)
Prolonged	23 (27.4)
Palpable distal pulsation	
Not done	**52 (61.9)**
Done	**32 (39.9)**
Palpable	7 (72.6)
Not palpable	25 (27.4)
Urine output	
Not measured	**52 (61.9)**
Measured	**32 (38.1)**
Normal	21 (25)
Oliguric	11 (13.1)
External bleeding	
Present	69 (82.1)
Absent	15 (17.9)

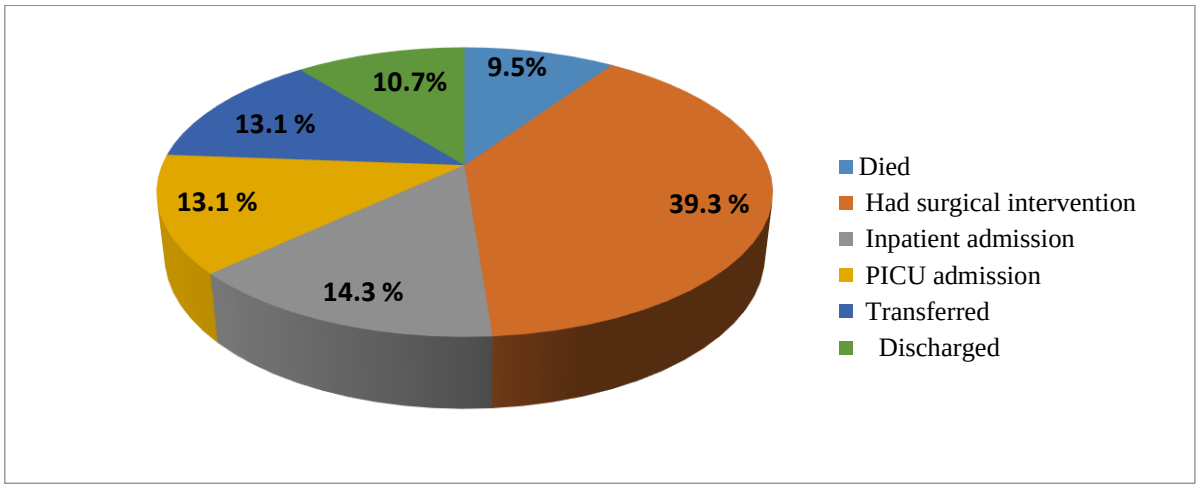

Figure (2): Mortality rate among pediatrics polytrauma patients

Figure **2** shows that the mortality rate of pediatrics polytrauma patients attending to the Emergency Department (ED) at the Suez Canal university Hospital was 9.5%.

Table (2): Association between age and blood pressure performance at the ER

Variables	Blood pressure performance		
	Done	not Done	p-value
Age category			
Preschool (2 – 5)	3 (6.2)	24 (66.7)	
Middle childhood (6 – 10)	26 (54.2)	8 (22.2)	**<0.001***
Young teen (11 – 13)	19 (39.6)	4 (11.1)	

***Significant.** Table **2** shows that performance of blood pressure among pediatric patients was significantly lower among patients with lower age ($p<0.001$).

Table (3): Association between fate of the patients and their clinical characteristics

Variables	Survived (n=76)	Died (n=8)	p-value
Airway, n (%)			
Patent	63 (82.9)	0 (0)	**<0.001***
At risk	13 (17.1)	8 (100)	
Breathing, n (%)			
Self-breathing	57 (75)	0 (0)	**<0.001***
Assisted breathing	19 (25)	8 (100)	
Pulse			
Tachycardia	49 (64.5)	0 (0)	
Normal range	18 (23.7)	0 (0)	**<0.001***
Bradycardia	9 (11.8)	8 (100)	
Blood pressure			
measured	32 (42.1)	4 (50)	0.72[b]
not measured	44 (57.9)	4 (50)	
Capillary refill			
measured	36 (47.4)	0 (0)	**0.009***
not measured	40 (52.6)	8 (100)	
Distal pulsation			
measured	26 (34.2)	6 (75)	0.059[b]
not measured	50 (65.8)	2 (25)	
Urine output			
measured	30 (39.5)	2 (25)	0.704
not measured	46 (60.5)	6 (75)	
External bleeding			
present	61 (80.3)	8 (100)	0.34
Absent	15 (19.7)	0 (0)	

***Significant.** Table 3 shows that mortality among pediatric polytrauma patients was significantly associated with obstructed airway, breathing difficulties, bradycardia and prolonged capillary refill.

Table (4): Association between fate of the patients and their fluid therapy

Variables	Survived (n=76)	Died (n=8)	p-value
Crystalloid			
Once	31 (40.8)	0 (0)	
Twice	35 (46.1)	2 (25)	**<0.001***
Three times	10 (13.2)	6 (75)	
Colloid			
Needed	38 (50)	6 (75)	0.269
Not needed	38 (50)	2 (25)	
Inotropic support			
Needed	17 (22.4)	8 (100)	**<0.001***
Not needed	59 (77.6)	0 (0)	

***Significant

Table **4** shows that about 75% of the patients who died in the ER needed more than 3 times crystalloid intake in addition to colloid and inotropic support ($p<0.001$).

DISCUSSION

The management of pediatric trauma usually represents a hard challenge due to the differences in anatomy, physiology and age-specific considerations. Achievement of the hemodynamic stability and the rapid recovery of tissue perfusion are major ones of these challenges[11].

We aimed to enhance the assessment and management of pediatric polytrauma patients' circulation by conducting this cross-sectional study on 84 patients who presented to the Emergency Department (ED) at Suez Canal University Hospital with such injuries by ATLS.

The mean age of our patients was 7.76 ± 3.46 years. The bulk of patients were from the center of childhood (6 – 10 years) age group (40.5%) followed by preschool children (2 – 5 years) who consisted 32.1% of the whole number. The smallest proportion was for the teenagers (11-13 years) forming only 27.4% of total patients. Similarly, **Liu *et al.*** [12] conducted a national pediatric trauma registry pilot study in Bahrain and reported the age groups (1-4 years) and (5-9 years) represented the most foremost ones representing 34% and 33%, respectively of the whole sample. A similar experience was discovered in research on trauma scores and the value they have in predicting the prognosis of pediatric polytrauma. Cohort patients primarily consisted of kids between the ages of 6 and 12, with kids between the ages of 1 and 5 making up the next largest demographic[13].

Males formed about 60.7% of the pediatric patients in the current study which comes in accordance with much of the literature [12-15]. The overrepresentation of males among trauma patients perhaps because boys are more inclined to play in hazardous environments without adult supervision.

Motor car accident was the most prevalent mechanism of trauma in the current study (47.6%) followed by falling from height (28.6%). Similarly, **Wendling-Keim *et al.*** [13] reported that car accidents and falls were the most common causes of polytrauma. **Alghnam *et al.*** [14] reported comparable findings in their study on the associations between mechanism of injury and duration of hospital stay among pediatric patients. The most common injury mechanism was falling (31.5%), followed by a motor vehicle collusion (MVC) (28.5%).

This variability could be explained that the mechanism of injury changes according to the age group. Children from one to four years old are particularly vulnerable to home injuries caused by falls or objects falling on them. Most pedestrian street injuries occur to older children, ages 5 to 9[14].

The vast majority of injuries occurred as a result of falls (750 out of 1328, 56.48 percent), and the proportion of younger children experiencing this mechanism of damage decreases as they get older (73.9 percent)[12].

Almost 60% of the pediatric trauma patients were transported to hospital via private car or taxi while 40% were brought by ambulance. **Liu *et al.*** [12] reported that in only 28.4% of pediatric trauma patients, ambulances were utilized those findings are in line with the results of previous study[11]. Similarly, **Alghnam *et al.*** [14] showed similar results as 64.7% of patients of their study were transported by private cars instead of ambulances. Moreover, they showed that private vehicle transport resulted in a 70% reduction in the likelihood of length of stay (LOS) compared to ambulance transport (OR: 0.3, 95% CI: 0.2–0.4). Patients who need an ambulance may have more serious injuries than those who can be driven to the hospital in their own cars. One possible explanation for this higher-than-expected estimate is a lack of knowledge on how to reach emergency services in a crisis[15].

About 50% of the patients had a Glasgow Coma Score (GCS) from 13 to 15 at presentation and only 25% of the patients had GCS < 8 at presentation. **Alyafei *et al.*** [16] also reported a mean GCS of 13.2 ± 3.5. In the study of **Wendling-Keimthe *et al.*** [13], 90.7% of patients, GCS was done, and the average score was 12.4 ± 3.9.

Moreover, in the current study, all patients with GCS <8 at presentation were died ($p<0.001$). Similarly, in the study of **El-Gamasy and his colleagues**[17], when comparing GCS between survivors and non-survivors, non-survivors had a significantly lower GCS. Similarly, a research by **Gill *et al.*** [18] demonstrated that GCS can predict long-term health consequences following a head injury.

The majority (75%) of our patients had patent airways and only 5 patients required respiratory adjuncts (6%) and 16 patients required intubation (19%). Self-breathing was reported in about 70% of patients. **El-Gamasy *et al.*** [17] undertook a study to

evaluate the accuracy of the pediatric trauma BIG score in predicting death in patients with multiple injuries, and found that only 25% of the patients had uncontrollable breathing problems.

After assessment of the association between age and blood pressure performance at the ER, it was shown that blood pressure measurement among pediatric patients was significantly lower among patients with lower age (p<0.001). About 66.7% of the patients whose blood pressure was not measured were in the 2-5 years' age group.

Additionally, blood pressure was measured in all patients, capillary refill assessment was not done in 42.6% of patients, distal pulsation was not assessed in 38.1% of patients, and urine output measurement was not performed in 61.9% of patients. Limited resources especially that used for early age group, limited number of physicians, together with the huge number of patients presenting to the ER at Suez Canal University Hospital from all age groups are all factors that may explain these missed elements of evaluation.

Moreover, regarding insertion of urinary catheter insertion to monitor urine output, there is a medico-legal element that a specialized Obs & Gyn physician is needed to insert a urinary catheter for virgin females. It is not readily available all the time and may limit the ability to monitor urine output for such category of patients.

Focused Assessment with Sonography for Trauma (FAST) is one of the most commonly used diagnostic imaging modalities within the first hour after a patient's arrival in the trauma centre. **Frellesen *et al.*** [19] reported that Free fluid observed by the FAST substantially linked with abdominal diseases (p<0.001), with 100% specificity. FAST showed a strong correlation with the results of the whole-body CT in terms of free fluid (WBCT) (p<0.0001). We found that survival of the studied patients was statistically significant associated with performing chest X-ray (p<0.012) and FAST study (p=0.024).

Wendling-Keim and coworkers[13] employed targeted abdominal sonography for trauma to determine the relationship between trauma scores and long-term outcomes in children who had had polytrauma (FAST, n = 65) and more advanced abdominal sonography (n = 6) that 28 patients were found to have loose fluids in their abdomen or pleura. During their time in the hospital, five of these patients underwent a direct laparotomy, while another five underwent additional surgical procedures. Twenty-eight of the patients did not have FAST or any kind of comprehensive abdominal sonography. Most of those situations included patients being transferred to another facility or initially being imaged using a technique other than CT scans (cranial CT, trauma CT, thoracic X-ray). Surgery was performed on unstable patients without preoperative imaging.

The results showed that mortality among pediatric polytrauma patients was significantly associated with obstructed airway (<0.001), breathing difficulties (<0.001). Additionally, it was found that 75% of the patients who had motor car accident were died. It was also noticed that the 8 died patients were from the younger age groups (preschool and middle childhood). However, it was not statistically significant results. Similarly, the study by **Nakayama *et al.***[20] found that the likelihood of survival following a controlled childhood injury did not vary significantly between age groups. Contrary to the findings of a study by **El-Gamasy and colleagues**[17], in which the average age of patients who did not make it through the study was significantly lower than that of those who did, this finding was seen (P = 0.01).

In the current study, 75 (89.3%) patients needed fluid replacement by crystalloid fluids and it was given once, twice, and three times to 6, 29, and 40 of them, respectively. Regarding blood component, about half of the patients needed blood while about 47% of the patients were actually given blood. About 30% of the patients needed inotropic support and they were actually given. Meanwhile, no patient had received massive transfusion protocol. Furthermore, our results showed that about 75%, 75%, and 100% of the patients who died in the ER needed more than 3 times crystalloid intake (p<0.001), colloids (p=<0.001), and inotropes (p<0.001), respectively.

There is still no consensus on the optimal volume of fluid for resuscitating children who have trauma. For adults, there is evidence to suggest early transfusion of packed red blood cells and restricted use of crystalloid fluid. According to the available data, excessive fluid resuscitation causes hemodilution of coagulation factors, which in turn increases coagulopathy and acidosis and can cause tissue injury because of tissue edema. According to the Advanced Trauma Life Support (ATLS) guidelines, only 1L, not 2L, of crystalloid is needed for adult trauma patients. On the other hand, three 20 ml/kg crystalloid boluses are advised prior to PRBC transfusion in pediatric trauma patients. Like American Heart Association (AHA) and Pediatric Advanced Life Support (PALS) recommends 60 ml/kg of crystalloid for hypovolemic shock in children, although the 2015 PALS update recognized the risk of intensive fluid resuscitation in some patients. They didn't talk about hemorrhagic shock at all. This shift in protocol, which calls for either immediate blood or 10 ml/kg aliquots of crystalloid before transfusion, was included in the 2015 edition of the Advanced Pediatric Life Support Update [21,22].

Finally, we observed some factors that we think they lead to the deaths in our study population which were the following: 50 % of the patients were transported with private vehicles (not ambulance) so this may take longer time, they didn't have close monitoring or primary medical support also due to the age group not every pre-hospital emergency medical member is trained on dealing with them so all these reasons made them present with compromised airway

(may due to local or central cause), all of them needed assisted breathing (which may due to chest cause) and we also noted the all deaths had presented at late stages of hypovolemic shock (bradycardia is a main sign) and also had external bleeding. GCS also was below 8 and its may be due to central causes and this probably made them liable to prolonged hypoxia and affected their prognosis.

CONCLUSION

The mortality rate of pediatrics polytrauma patients attending to the Emergency Department at Suez Canal University Hospital was 9.5% and was significantly associated with obstructed airway, breathing difficulties, bradycardia, and prolonged capillary refill. Survival of the studied patients was statistically significant associated with performing chest X-ray ($p<0.001$), pelvis X-ray ($p<0.012$) and FAST study ($p=0.024$). So, adherence to the international guidelines in evaluation and management of pediatric polytrauma patients is a cornerstone in improving outcomes and decreasing mortality. Furthermore, the ER environment is stressful and eventful, which requires a systematic approach to limit pitfalls and improve performance.

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Author contribution: Authors contributed equally in the study.

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