



ORIGINAL ARTICLE

Impact of implementation of sequential trauma education programs (STEPs) course on missed injuries in emergency polytrauma patients, Ismailia, Egypt

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ABSTRACT

Introduction: Trauma deaths account for 8% of all deaths in Egypt. Patients with multiple injuries are at high risk but may be saved with a good triage system and a well-trained trauma team in dedicated institutions. The incidence of missed injuries in the Emergency Centre (EC) of Suez Canal University Hospital (SCUH) was found to be 9.0% after applying Advanced Trauma Life Support (ATLS) guidelines. However, this rate is still high compared with many trauma centers.

Aim: Improve the quality of management of polytrauma patients by decreasing the incidence of missed injuries by implementing the Sequential Trauma Education Programs (STEPs) course in the EC at SCUH.

Methods: This interventional training study was conducted in the SCUH EC that adheres to CONSORT guidelines. The study was conducted during the one month precourse and for 6 months after the implementation of the STEP course for EC physicians. Overall, 458 polytrauma patients were randomly selected, of which 45 were found to have missed injuries after applying the inclusion and exclusion criteria. We assessed the clinical relevance of these cases for missed injuries before and after the STEP course.

Results: Overall, 45 patients were found to have missed injuries, of which 15 (12%) were pre-STEPs and 30 (9%) were post-STEPs course. The STEP course significantly increased adherence to vital data recording, but the reduction of missed injuries (3.0%) was not statistically significant in relation to demographic and trauma findings. However, the decrease in missed injuries in the post-STEPs course group was an essential clinically significant finding.

Conclusion: STEP course implementation decreased the incidence of missed injuries in polytrauma patients. Thus, the STEP course can be considered at the same level of other advanced trauma courses as a training skills program or possibly better in dealing with trauma patients. Repetition of this course by physicians should be mandatory to prevent more missed injuries. Therefore, the validation of STEP course certification should be completed at least every two years to help decrease the number of missed injuries, especially in low-income countries and low-resource settings.

Introduction

Trauma is considered the sixth leading cause of death worldwide. In 2004, approximately 5.8 million deaths were estimated to be from injuries, and injury deaths in Egypt accounted for 8% of all deaths. Trauma was the eighth leading cause of death in Egypt 2010 [1].

Polytrauma is defined as a clinical state after injuries to the body that involves multiple systems or severe injuries to the patient that may result in death within 24 hours, injury severity score (ISS) of 16 or more, intensive care unit (ICU) stay for one day or more, or more than two units of blood transfusion [2]. Multiple injuries lead to significant disability and decrease the chances of early return to work. Polytrauma

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patients who are dangerously injured may be saved with a good triage system and a well-trained trauma team at dedicated institutions [3].

ISS, the most frequently used trauma score, was first published by Baker et al. in 1974 and is used to describe injury severity based purely on anatomical findings as defined in the Abbreviated Injury Scale (AIS), which classifies the body into nine regions. The severity of each individual injury is graded on a scale from one to six points: one point for minor injuries and six points for untreatable, mostly lethal injuries. To calculate the ISS, each AIS score is assigned to one of six different body regions. The ISS is calculated as the sum of the squares of the highest AIS code in each of the three most severely affected body regions [4].

Improvement in the organization of trauma services should be achievable in almost every setting and may represent a cost-effective way of improving patient outcomes [5]. However, many lives have been saved through inexpensive modifications in education, organization, and availability of simple pieces of equipment. Such changes greatly simplify decisions and actions [6].

Missed injuries are defined as injuries detected in a period six hours after the traumatic event. Missed injuries are classified into three groups: minor, major, and life-threatening. The incidence of missed injuries at the emergency centre (EC) of SCUH was 9.0% after applying Advanced Trauma Life Support (ATLS) guidelines, which is still high compared with many trauma centers [7].

Deviations from ATLS protocols are common, ranging from 23% to 53%. The compliance rate can affect patient outcome and can serve as a surrogate marker for quality assessment of a trauma system. In a previous study, Elbaih et al. applied ATLS guidelines without a training program. In the SCUH EC, there is no unified policy in managing polytrauma patients [5,8].

To meet the need for improved trauma care in Egypt, the STEPs course was created through a collaborative effort of physicians in the United States and Egypt. In 2008, multiple Egyptian medical schools and the Emergency Medicine Board implemented required STEPs for physician training [9].

There are more than 24 certified Egyptian STEPs trainers, and 30 courses were offered, in which more than 1000 physicians were trained, with the last course held in Khartoum, Sudan, in April 2018. The course is supplemented to highlight various trauma care topics adopted for lower- and middle-income countries [10].

Herein, because the incidence of missed injuries is still high compared with many trauma centers, we seek clinical evidence-based management of trauma patients through the STEPs course. We aim to decrease this incidence by attempting to improve the quality of management of polytrauma patients by decreasing the incidence of missed injuries through the implementation of the STEPs course in the SCUH EC.

Methods

Main objective was to improve the quality of management of polytrauma patients by decreasing the incidence of missed injuries through the implementation of the STEPs course in the SCUH EC. The research question was “Does implementation of the STEPs course for EC physicians decrease the incidence of missed injuries in the Emergency polytrauma patients?” Secondary objectives were 1) to evaluate adherence to STEPs guidelines at Emergency Centre of Suez Canal University, and 2) to know obstacles which interfere with application of STEPs guidelines.

This study was a cross-sectional, interventional study including all polytrauma patients treated in the SCUH EC that my study adheres to CONSORT guidelines. The STEPs course was used in limited-resource settings and was designed to improve services in ECs by training residents and physicians with good materials in a 4-day course. Materials included a combination of lectures, interactive sessions (e.g., radiology review, splinting workshop, and airway workshop), and a half-day veterinary procedure laboratory. So, in our study depending on STEPs course guidelines.

The target patients include all polytrauma patients treated in the SCUH EC during the one-month precourse and for six months after the implementation of the STEPs course for ER physicians, with the application of the inclusion and exclusion criteria that my study adheres to CONSORT guidelines.

Inclusion criteria were, 1) all ages, 2) both sexes, and 3) patients with polytrauma criteria: death within 24 hours, ISS of 16 or more, ICU stay of 1 day or more, or more than two units of blood transfusion. Exclusion criteria were 1) patients transferred from other hospitals after undergoing any medical or surgical procedure, 2) patients discharged by his or her demand or transferred to another hospital, and 3) patients with injuries that occurred more than 24 hours before presentation

Step course design

All EC physicians, including residents and assistant lecturers, attended the STEPs course to improve services in the EC. The materials for the STEPs course (4 days) included a combination of lectures, interactive sessions (e.g., radiology review, splinting workshop, and airway workshop), and a half-day veterinary procedure laboratory.

After an Airway, Breathing, Circulation, Disability and Exposure (ABCDE) approach, all patients were subjected to full history-taking, including age, sex, occupation, mode of trauma, time of trauma, arrival, and resuscitation. A secondary survey included the following: A) Allergies, Medications current use, Past illness, Last meal, Event (AMPLE) history; B) Clinical examination, including the following: 1) general examination: pulse, blood pressure, respiratory rate, temperature, and oxygen saturation, and 2) local examination: head and neck, chest, abdomen, pelvis, and extremities, as well as Glasgow coma score; C) investigations: 1) Laboratory investigation such as complete blood count, blood-typing, crossmatching, random blood sugar, arterial blood gases, serum creatinine, and liver function test, if needed, and 2) radiographic: X-ray, ultrasonography, and computed tomography scan according to clinical picture of the patient; and C) initial diagnosis and decision.

After patient admission, all patients were frequently followed up through visit (follow-up time frame, 12 hours), during which the following happened: 1) rechecked airway, breathing, and circulation, and treat any life-threatening conditions, if found; 2) all patients were subjected to full history and examination and ordering of new radiology according to new findings to discover missed injuries; and 3) any missed injury cases were exactly diagnosed six or twelve hours after the traumatic event.

Missed injuries were defined as injuries detected within twelve hours after a traumatic event. The incidence of missed injuries in the SCUH EC is 9.0%, which was still high compared with many trauma centers. Moreover, most missed injuries have increased the length of stay in the hospital and affected the outcome of polytrauma patients. On the other hand, injuries identified and dedicated after twelve hours of admission. To assess the clinical relevance of these overlooked injuries, missed injuries were classified into three groups: minor, major, and life-threatening [5]. Minor injuries included injuries of the hand, wrist, foot, ankle, and forearm; noncomplex soft tissue injuries and fractures; and rupture of ligaments and muscle tendons. Major injuries included skull injuries; neurological and arterial lesions; liver, spleen, and intestinal lacerations; and femoral, humeral, pelvic, and spine fractures and dislocations. Life-threatening injuries included injuries of main vessels in the thorax, hemothorax, and pneumothorax [11,12].

Missed injury cases diagnosed after finished services in EC were documented in progress notes, along with definitive diagnosis and final decisions taken. Moreover, Egyptian law allows a time frame of 48 hours to all emergency case services, which is free of charge. Thus, the short follow-up outcome was 48 hours in the EC, inpatient ward, or ICU to detect any types of missed injuries. The EC staff and attending surgical registrars wrote the progress notes within six and twelve hours after the traumatic event. We compared the criteria of the initial diagnosis

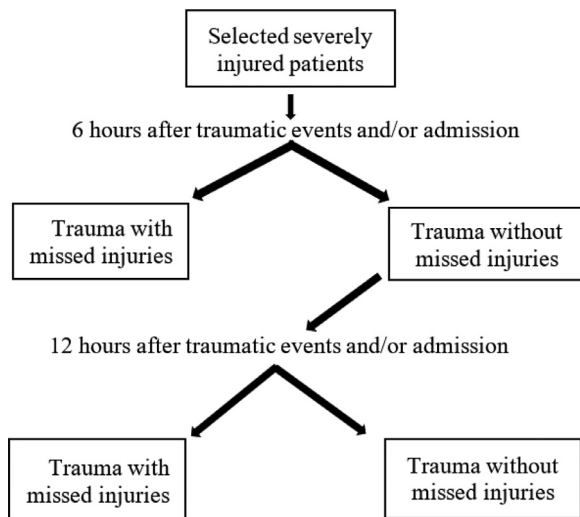


Fig. 1. Summary algorithm for the selection of the study patients

with the injuries listed in the progress notes, investigation reports, and discharge summary, to assess for discovered missed injuries.

See Fig. 1 for the summary algorithm for the selection of the study patients.

Trauma data collection for all polytrauma patients with an ABCD approach included the patient's history, clinical examination, laboratory investigations, and progressive notes six and twelve hours after the traumatic event. Data was noted on a data collection form to compare the initial diagnosis.

The collected data were coded, tabulated, and statistically analyzed using IBM SPSS statistics software, version 22.0 (IBM Corp., Armonk, NY, USA) and Microsoft Office Excel 2007 (Microsoft Corp., Redmond, WA, USA). Descriptive statistics were compiled for qualitative data as numbers and percentages. Inferential analyses were calculated for qualitative variables using the chi-square test and Fisher's exact test for variables with small, expected numbers. *P* values less than 0.050 were considered significant.

All patients provided consent to participate in the study without affecting their course of treatment according to institutional approvals obtained and approvals of the Research Ethics Committee of the Faculty of Medicine, Suez Canal University (reference number, 3591), and the Institutional Review Board of the University of Maryland (exempt under 45 CFR 46.101(b) from institutional review board review). Confidentiality of data and an explanation of our study were provided to the participants before informed consent was obtained from each patient or relative. The information provided included the aim of the research, a brief scientific background, an explanation of the aim in a simple manner to be understood by the common people, all direct and indirect benefits, no harmful maneuvers used, and the researchers' phone number and all possible communicating methods identified to the participant.

Results

This study was a descriptive cross-sectional, interventional study conducted to evaluate and improve the quality of management of polytrauma patients by decreasing the incidence of missed injuries through the implementation of the STEPs course in the SCUH EC. The study included 458 polytrauma patients who presented within twelve hours from the time of trauma, between August 10, 2019, and March 9, 2020. All patients underwent routine and advanced investigations for the initial diagnosis and decision for clinical practice. In addition, our study revealed that most of the patients (pre-STEPs, 62.4%; post-STEPs, 65.2%) were between the ages of 18 and 60 years old. Moreover, male patients comprised 86.4% of the pre-STEPs group and 88.0% of the post-STEPs

group, indicating a male predominance. In addition, our study revealed that 52.8% pre-STEPs and 48.9% post-STEPs were injured by Motor Car Accidents (MCA), which means that more than half of the studied patients were involved in MCAs. Most of the patients with missed injuries (9 [60.0%] in the pre-STEPs group and 20 [66.7%] in the post-STEPs group) arrived to the hospital at night.

Table 1 shows a comparison between pre- and post-STEPs regarding demographic and trauma findings among a total of 458 polytrauma cases. Moreover, 15 (12%) were polytrauma patients with missed injuries in the pre-STEPs group and 30 (9%) polytrauma patients with missed injuries in the post-STEPs group. According to the type of missed injuries in both groups, there was a statistically significant decrease in missed injuries in post-course cases. However, there were 413 polytrauma patients without missed injuries compared with 45 polytrauma patients with missed injuries.

Among the polytrauma patients included in this study, head and facial injuries ($n = 59$, 47.2%) and injuries to the extremities ($n = 52$, 41.6%) were most common in the pre-STEPs group. In the post-STEPs group, the most common sites of injury were the head and neck ($n = 171$, 51.3%) and the extremities ($n = 129$, 38.7%). Among those with missed injuries, most were injuries to the head and face ($n = 6$, 40.0%) and the extremities ($n = 7$, 46.7%) in the pre-STEPs group and the head and face ($n = 15$, 50%) and the extremities ($n = 12$, 40.0%) in the post-STEPs group.

Most of the missed injuries in both groups were classified as mild (pre-STEPs, 53.3%; post-STEPs, 76.7%). However, in the pre-STEPs group, there was one case (6.7%) of life-threatening missed injuries. Most of the missed injuries in both groups were classified as Glasgow coma scale 13–15 (pre-STEPs, 100%; post-STEPs, 96.7%), which is not significantly different.

Vital data records were missing for some cases, such as the 64.8% of patients who were not assessed for respiratory rate in the pre-STEPs group. In addition, vital records of 29.4% of the patients in the pre-STEPs group and 100% of patients in the post-STEPs group had a respiratory rate of less than 29 cycles per minute. However, 11.8% of patients in the pre-STEPs group and 9.7% of patients in the post-STEPs group experienced tachycardia greater than 100 beats per minute, and 58.4% of patients in the pre-STEPs group were not assessed for heart rate. In addition, 3.2% of patients in the post-STEPs group had systolic blood pressure less than 90 mmHg; 40.8% of patients in the pre-STEPs group were not assessed for systolic blood pressure. There was a significant difference between the pre- and post-STEPs groups in respiratory rate, heart rate, and systolic blood pressure.

Table 1 summarises that the missed trauma was not significantly less frequent post-STEPs than in the pre-STEPs group (12.0% and 9.0%, respectively).

In all cases, there was no significant difference between pre- and post-STEPs regarding age, sex, mechanism of trauma, and time of trauma. Facial injury was significantly more frequent in the pre-STEPs group, whereas head and spine were significantly more frequent post-STEPs. Severity was significantly higher in the pre-STEPs cases. The incidence of missing vital data records was significantly less frequent in the post-STEPs cases.

In missed cases, there was no significant difference between the pre- and post-STEPs groups regarding age, sex, mechanism of trauma, site, time, and severity of trauma. The incidence of missing vital data records was significantly less frequent in the post-STEPs cases.

Fig. 2 shows that the mean number of missed injuries from the first to the fourth week before the course was four cases per week. However, Fig. 3 shows that the number of missed injuries increased from the first to the sixth month after the STEPs course (two and seven cases, respectively).

Table 2 shows a comparison between missed injury cases in the pre- and post-STEPs groups regarding missing characteristics. This research shows that all patients with missed injuries in the pre-STEPs group had undergone X-ray and ultrasound, followed by 40% who had undergone

Table 1
Comparison between pre- and post-STEPs regarding demographic and trauma findings

Variables	All cases			Missed cases				
	Pre-STEPs (N = 125)	Post-STEPs (N = 333)	P value	Pre-STEPs (N = 15)	Post-STEPs (N = 30)	P value		
Age, years	<18	41 (32.8%)	# 0.853	8 (53.3%)	7 (23.3%)	§ 0.058		
	18–60	78 (62.4%)		6 (40.0%)	22 (73.3%)			
	>60	6 (4.8%)		1 (6.7%)	1 (3.3%)			
Sex	Male	108 (86.4%)	# 0.674	12 (80.0%)	28 (93.3%)	§ 0.315		
	Female	17 (13.6%)		3 (20.0%)	2 (6.7%)			
Mechanism of trauma	Motorcycle	66 (52.8%)	# 0.175	10 (66.7%)	12 (40.0%)	§ 0.396		
	Assault	39 (31.2%)		4 (26.7%)	11 (36.7%)			
	FFH	18 (14.4%)		77 (23.1%)	0 (0.0%)		3 (10.0%)	
	DHT	2 (1.6%)		8 (2.4%)	1 (6.7%)		4 (13.3%)	
Time	Day	49 (39.2%)	# 0.402	6 (40.0%)	10 (33.3%)	# 0.660		
	Night	76 (60.8%)		188 (56.5%)	9 (60.0%)		20 (66.7%)	
Site of trauma	Face	59 (47.2%)	# 0.021*	6 (40.0%)	10 (33.3%)	# 0.660		
	Extremities	52 (41.6%)		129 (38.7%)	7 (46.7%)		12 (40.0%)	
	Chest	7 (5.6%)		11 (3.3%)	# 0.577		1 (3.3%)	1 (3.3%)
	Abdomen	7 (5.6%)		11 (3.3%)	§ 0.283		1 (6.7%)	1 (3.3%)
	Head	0 (0.0%)		53 (15.9%)	§ 0.283		0 (0.0%)	5 (16.7%)
	Spine	0 (0.0%)		11 (3.3%)	# <0.001*		0 (0.0%)	0 (0.0%)
					§ 0.040*		11 (3.3%)	1 (3.3%)
Injury severity	Mild	65 (52.0%)	# <0.001*	8 (53.3%)	23 (76.7%)	§ 0.158		
	Major	54 (43.2%)		97 (29.1%)	6 (40.0%)		7 (23.3%)	
	Life-threatening	6 (4.8%)		0 (0.0%)	1 (6.7%)		0 (0.0%)	
GCS	8–11	0 (0.0%)	§ 0.040*	0 (0.0%)	1 (3.3%)	§ 0.999		
	13–15	125 (100.0%)		322 (96.7%)	15 (100.0%)		29 (96.7%)	
Vital data record missing	Heart rate	73 (58.4%)	# <0.001*	9 (60.0%)	0 (0.0%)	§ <0.001*		
	Blood pressure	51 (40.8%)		0 (0.0%)	7 (46.7%)			
	Respiratory rate	81 (64.8%)		0 (0.0%)	9 (60.0%)		0 (0.0%)	
Missed injury		15 (12.0%)	# 0.338					

Chi-square test.

§ Fisher's exact test.

* Significant. DHT, Direct Head Trauma; FFA, fall from height; GCS, Glasgow coma scale.

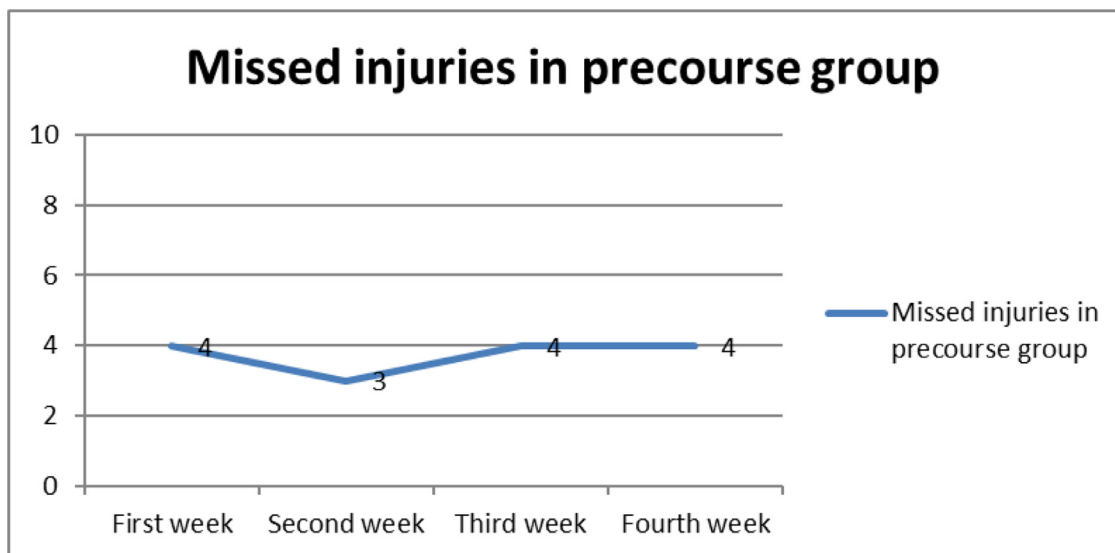


Fig. 2. Number of missed injuries per month in pre-STEPs

full examination for the final detection and diagnosis of missed injuries. In the post-STEPs group, all patients with missed injuries had undergone X-ray, ultrasound, and full examination to determine and detect missed injuries. No significant differences were noted in terms of missing characteristics between missed injury cases in the pre- and post-STEPs groups.

Table 2 shows that there was a statistically significant difference between the groups regarding contributing factors of missed injuries. In the pre- and post-STEPs groups, respectively, three (20%) and nine (30%) were caused by inadequate diagnostic workup, six (40%) and nine (30%) by deficiency in the physical examination, zero and three (10%) by incomplete assessment owing to patient instability, and six

(40%) and nine (30%) by incorrect interpretation of the imaging. In addition, the study revealed that most of the missed injuries in both groups had delayed time of final diagnosis within 6 hours (pre-STEPs, 93.3%; post-STEPs, 76.7%).

Table 3 summarises a comparison between missed and non-missed cases regarding demographic and trauma findings in the pre- and post-STEPs groups. There was no significant difference between missed and non-missed cases regarding demographic and trauma findings. In post-STEPs cases, there was no significant difference between missed and non-missed cases regarding demographic and trauma findings, except that the mechanism of trauma was significantly different. Assault and DHT were more frequent in missed cases, whereas motorcycle accidents

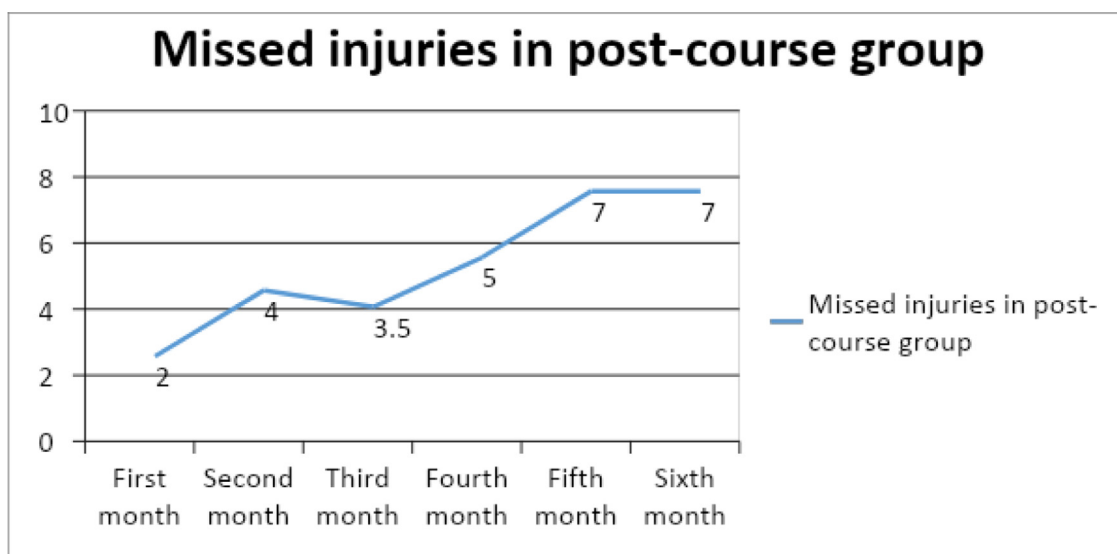


Fig. 3. Number of missed injuries per month post-STEPs

Table 2

Comparison between missed injury cases in pre- and post-STEPs regarding missing characteristics

Variables	Pre-STEPs (N = 15)	Post-STEPs (N = 30)	P value	
Method of diagnosis	X-ray	15 (100.0%)	30 (100.0%)	
	US	15 (100.0%)	30 (100.0%)	
	CT	2 (13.3%)	11 (36.7%)	§0.165
	MRI	0 (0.0%)	0 (0.0%)	–
Contributing factor	Inadequate diagnostic workup	3 (20.0%)	9 (30.0%)	§0.722
	Deficiency in examination	6 (40.0%)	9 (30.0%)	#0.502
	Incomplete assessment	0 (0.0%)	3 (10.0%)	§0.540
	Incorrect interpretation	6 (40.0%)	9 (30.0%)	#0.502
Delay time	6 hours	14 (93.3%)	23 (76.7%)	§0.236
	12 hours	1 (6.7%)	7 (23.3%)	

Chi-square test.

§ Fisher’s exact test.*Significant.CT, computed tomography; MRI, magnetic resonance imaging; US, ultrasound.

Table 3

Comparison between missed and non-missed cases regarding demographic and trauma findings

Variables	Pre-STEPs			Post-STEPs			
	Missed (N = 15)	Not missed (N = 110)	P value	Missed (N = 30)	Not missed (N = 303)	P value	
Age, years	<18	8 (53.3%)	33 (30.0%)	§0.098	7 (23.3%)	95 (31.4%)	#0.778
	18–60	6 (40.0%)	72 (65.5%)		22 (73.3%)	195 (64.4%)	
	>60	1 (6.7%)	5 (4.5%)		1 (3.3%)	13 (4.3%)	
Sex	Male	12 (80.0%)	96 (87.3%)	§0.429	28 (93.3%)	265 (87.5%)	§0.555
	Female	3 (20.0%)	14 (12.7%)		2 (6.7%)	38 (12.5%)	
Mechanism of trauma	Motorcycle	10 (66.7%)	56 (50.9%)	§0.115	12 (40.0%)	151 (49.8%)	§0.002*
	Assault	4 (26.7%)	35 (31.8%)		11 (36.7%)	74 (24.4%)	
	FFH	0 (0.0%)	18 (16.4%)		3 (10.0%)	74 (24.4%)	
	DHT	1 (6.7%)	1 (0.9%)		4 (13.3%)	4 (1.3%)	
Time	Night	6 (40.0%)	43 (39.1%)	#0.946	10 (33.3%)	135 (44.6%)	#0.237
	Day	9 (60.0%)	67 (60.9%)		20 (66.7%)	168 (55.4%)	
Site of trauma	Face	6 (40.0%)	53 (48.2%)	#0.552	10 (33.3%)	108 (35.6%)	#0.801
	Extremities	7 (46.7%)	45 (40.9%)	#0.671	12 (40.0%)	117 (38.6%)	#0.882
	Chest	1 (6.7%)	6 (5.5%)	§0.999	1 (3.3%)	10 (3.3%)	§0.999
	Abdomen	1 (6.7%)	6 (5.5%)	§0.999	1 (3.3%)	10 (3.3%)	§0.999
	Head	0 (0.0%)	0 (0.0%)	–	5 (16.7%)	48 (15.8%)	§0.799
	Spine	0 (0.0%)	0 (0.0%)	–	1 (3.3%)	10 (3.3%)	§0.999
Injury severity	Mild	8 (53.3%)	57 (51.8%)	#0.919	23 (76.7%)	213 (70.3%)	#0.464
	Major	6 (40.0%)	48 (43.6%)		7 (23.3%)	90 (29.7%)	
	Life threatening	1 (6.7%)	5 (4.5%)		0 (0.0%)	0 (0.0%)	
GCS	8-11	0 (0.0%)	0 (0.0%)	–	1 (3.3%)	10 (3.3%)	§0.999
	13-15	15 (100.0)	110 (100.0)		29 (96.7%)	293 (96.7%)	
Vital data record missing	Heart rate	9 (60.0%)	64 (58.2%)	#0.893	0 (0.0%)	0 (0.0%)	–
	Blood pressure	7 (46.7%)	44 (40.0%)	#0.622	0 (0.0%)	0 (0.0%)	–
	Respiratory rate	9 (60.0%)	72 (65.5%)	#0.678	0 (0.0%)	0 (0.0%)	–

Chi-square test.

§ Fisher’s exact test.SignificantDHT, Direct Head Trauma; FFA, fall from height; GCS, Glasgow coma scale.

and falls from heights were less frequent in missed cases. Thus, our results shown in this table conclude that the STEPs course significantly increased adherence to vital data recording but that the reduction of missed injuries (3.0%) was not statistically significant in relation to demographic and trauma findings but was an essential clinically significant finding.

Discussion

The selection of the right manner at the right time is fundamental in managing trauma patients. Approach, skills trauma programs, reliable, bedside, and rapidly accomplished routine investigations can be pivotal. These skills trauma programs should be differentiated between patients with life-threatening conditions and others with hidden injuries who are better with additional diagnostic workup, patients in whom additional diagnostic workup is unnecessary, and patients requiring surgical intervention, without risking the patient's clinical outcome.

Skills trauma programs include those such as the STEPs course, which was created through a collaborative effort of physicians in the United States and Egypt. One of the aims of this course was to create high-quality, modular, and sustainable trauma skills care course that can be adopted by lower- or middle-income countries [10].

Missed injuries in trauma patients remain a worldwide problem, especially in trauma centers. Thus, the implementation of trauma courses (e.g., STEPs, ATLS, and European Trauma Course) should be mandatory for all EC physicians to minimize the occurrence and incidence of missed injuries. This would serve to help decrease morbidity and mortality among trauma patients. And still paucity of knowledge and information regarding missed injuries in Egypt [12].

This interventional training study conducted in the SCUH EC was intended to improve the management process for polytrauma patients by evaluating and decreasing the incidence of missed injuries after the implementation of the STEPs course. This study revealed that, of the 458 polytrauma patients, 64.6% were between the ages of 18 and 60 years old and 87.5% were men. In addition, according to the mechanism of trauma, 229 (50%) of the patients were injured in MCAs.

Our results agree with those in a study performed by Kozaci et al., which was conducted at the Antalya Education and Research Hospital in Turkey between June 2015 and March 2018, in which the mean age of the study population was 38 ± 20 years [13].

Road traffic crashes are among the world's most preventable public health problems. According to the World Health Organization, there were 1.25 million road traffic deaths in 2013, a number that has remained fairly constant since 2007 despite the increase in global motorization and population and the predicted rise in deaths [14]. In our study, MCA was responsible for 52.8% of injuries in the pre-STEPS group and 50% in the post-STEPS group, followed by assault (pre-STEPS, 31.2%; post-STEPS, 14.4%) and falling from heights (pre-STEPS, 25.5%; post-STEPS, 23.1%). These results agree with another study conducted by Mahmood et al., which was published in January 2016, in which road traffic accidents, assault, and fall from heights were the most common mechanisms of injury among 993 Egyptian patients [16].

Our study showed that, based on vital data records that were missing, there was a significant difference between the pre- and post-STEPS groups in respiratory rate, heart rate, and systolic blood pressure but that there was no significance difference in Glasgow coma scale between the groups.

All polytrauma patients entered the resuscitation trauma room once they arrived at the ED. We followed the STEPs course principles and treated life-threatening conditions if found. Patients were then subjected to full history and secondary survey, as well as progressive notes for the detection of missed injuries according to the clinical picture of the patients. Our study included 458 polytrauma cases, of which 15 (12%) had missed injuries in the pre-STEPS group and 30 (9%) had missed injuries in the post-STEPS group. However, there were 413 polytrauma patients without missed injuries.

Our study showed that the site of polytrauma was the head and facial injuries in 59 (47.2%) cases and the extremities in 52 (41.6%) cases in the pre-STEPS group. However, in the post-STEPS group, the site of polytrauma was the head and neck in 171 (51.3%) cases and the extremities in 129 (38.7%) cases. This agrees with a study by Elbaih et al., who reported on 300 multiple trauma patients. Injuries of the extremities and pelvis were the most common in trauma patients (43%), and the head and neck (62%) was the only injury showing a significant association with mortality ($P < 0.05$) in contrast with other injuries ($P > 0.05$).

In our study, there were 15 (12%) missed injuries in the pre-STEPS group and 30 (9%) in the post-STEPS group. According to the type of missed injuries in both groups, the reduction of missed injuries (3.0%) was not statistically significant in relation to demographic and trauma findings but was an essential clinically significant finding to decrease the number of missed injuries in post-STEPS cases. This agrees with a study by Elbaih et al., who reported that the incidence of missed injuries in the study was 9.0% after the ATLS guidelines were applied and all life-threatening conditions were treated, if present, with a short follow-up outcome of 28 days, which is still high, compared with many trauma centers [5].

Our study showed that most of the missed injuries in both groups were mild (pre-STEPS, 53.3%; post-STEPS, 76.7%), but there was one case (6.7%) of missed life-threatening injuries in the pre-STEPS group. This agrees with a study by Elbaih et al., which reported that injuries in the head and neck were frequently missed (32.2%), followed by injuries of the extremities (28.6%), chest injuries (17.9%), abdomen and pelvis injuries (14.2%), and spine injuries (7.1%) [5].

Our study showed that there was one case (6.7%) of life-threatening missed injuries in the pre-STEPS course group but no cases (0%) in the post-STEPS group. This indicates that training programs, such as the STEPs course, for physicians should be mandatory and can affect the outcome of polytrauma patients by decreasing the incidence of life-threatening missed injuries. This agrees with a study by Pfeifer et al., who reported that, to reduce the rate of missed injuries, we must focus on unconscious and intubated patients with severe trauma (increased ISS) and brain injuries (decreased Glasgow coma scale) during the primary and secondary surveys by applying repeated training programs [11].

These results also match those of Chalya et al., who found that mortality in patients with missed injuries was 19.8% compared with 8.7% in patients without missed injuries ($P < 0.001$). Among deaths in patients with missed injuries, 57.9% were directly attributable to missed injuries, indicating that missed injuries should be detected early [12].

Our study showed that there was statistically significant difference between the contributing factors of missed injuries in the pre- and post-STEPS groups, respectively: three (20%) and nine (30%) were caused by inadequate diagnostic workup, six (40%) and nine (30%) by deficiency in physical examination, zero and three (10%) by incomplete assessment owing to patient instability, and six (40%) and nine (30%) by incorrect interpretation of imaging in traumatic patients. This corresponds with the findings of Elbaih et al., who reported that clinical error was the most frequent cause of missed injuries (42.9% in our study). Deficiency in physical examination was the second cause (35.7%), followed by incomplete assessment owing to patient instability (10.7%) and incorrect interpretation of imaging in (10.7%) [5,18,19].

Thus, repeated completion of the trauma STEPs course or other advanced trauma courses are essential for physicians to decrease contributing factors that increase the incidence of missed injuries. Our study showed that most of the missed injuries in both groups had delayed time of final diagnosis within 6 hours (pre-STEPS, 93.3%; post-STEPS, 76.7%). However, most of the patients (pre-STEPS, 9 [60.0%]; post-STEPS, 20 [66.7%]) had missed injuries after arriving at the hospital at night. This also matches the findings of Elbaih et al., who noted high rates of missed injuries (59.2%) in patients arriving during the night compared with 40.8% among patients arriving during the day [5]. The high rates of missed injuries among night arrivals can be explained by

the fact that well-trained ED physicians and senior surgical team members, which we found to be vital in the diagnosis of missed injuries, were unlikely to be present during night hours, unless called for difficult cases. In our resource-limited setting, in which staff shortage is a challenging problem, redistribution of the few available staff should be conducted to address this problem.

This research shows that all patients with missed injuries in the pre-STEPs group underwent X-ray and ultrasound, and 40% underwent full examination for the final detection and diagnosis of missed injuries. Among the patients with missed injuries in the post-STEPs group, all underwent X-ray, ultrasound, and full examination for the determination and detection of missed injuries. No significant difference was noted between missed injury cases in the pre- and post-STEPs groups regarding missing characteristics.

This agrees with another study by Elbaih et al., which reported a lack of admission X-rays of the specific area of injury (46.3%–53.8%) and misinterpreted X-rays (15%–34.9%) as main radiological factors contributing to missed diagnosis. Further factors noted were clinical inexperience (26.5%) and assessment errors (33.8%–60.5%). Other investigations have found additional contributing factors such as technical errors, inadequate X-rays, interrupted diagnosis, and neighboring injuries. The authors found that, in 50% of cases, more than one factor was responsible [5,17].

This research showed 15 (12%) missed injuries in the pre-STEPs group and 30 (9%) in the post-STEPs group. Most of the missed injuries in both groups were classified as mild (pre-STEPs, 53.3%; post-STEPs, 76.7%), but there was one patient (6.7%) with missed life-threatening injuries in the pre-STEPs group. After the STEPs program implementation and the resulting increase in skills through training, the rate of missed injuries decreased, and no life-threatening missed injuries were found. Elbaih et al. reported that the incidence of missed injuries in their study was 9.0% after the ATLS guidelines were applied and all the life-threatening conditions were treated, if present [5].

In our study, the incidence of missed injuries from the first to fourth week before the course was four cases per week. However, the number of missed injuries increased from the first to the sixth month after the course (two and seven cases, respectively), mostly owing to the increase in skills after the STEPs course for EC physicians, which initially resulted in a decreased rate of missed injuries but began to elevate again with time after the implementation. The loss of scientific knowledge and skills then affects the outcome of polytrauma patients through increased incidence of missed injuries. Therefore, refresher or repeated courses for physicians should be mandatory to prevent missed injuries. The validation of the STEPs course certificate should not last more than two years.

The STEPs principles deal with all polytrauma or major trauma patients, defined by an ISS greater than 16 for all age groups and sexes seen in the ED. For the purpose of this study, early detection of missed injuries was defined as injury detected and exactly diagnosed six or twelve hours after the traumatic event.

The STEPs course was developed in 2006 at the University of Maryland, based in part on the World Health Organization's emergency and surgical care materials, and designed to introduce course participants to basic concepts of injury management. After the award of the National Institutes of Health, Egyptian officials and Ain Shams University requested that the University of Maryland faculty provide the American College of Surgeons ATLS course. However, this was impossible at the time owing to the lack of in-country infrastructure required by the international ATLS process, implementation costs, and difficulty in adapting the course to limited-resource settings. The STEPs course was designed to improve services in EDs by training residents and physicians with good materials in a four-day course. Materials include a combination of lectures, interactive sessions (e.g., radiology review, splinting workshop, and airway workshop), and a half-day veterinary procedure laboratory. So, in our study depending on STEPs course guidelines [10].

The ATLS course by the American College of Surgeons introduced primary and secondary surveys in the management of multiple traumatized patients to allow for the prioritization of the most life-threatening injuries and to address all other injuries, respectively. Despite such detailed and standardized treatment principles, some injuries still escape detection during these two phases. However, most studies of missed injuries report an incidence of 0.6%–65%, depending on how a missed injury was defined and the type of injury considered [11,15].

After the implementation of the STEPs course in our study, the incidence of missed injuries decreased from 12% in pre-STEPs to 9% in post-STEPs, corresponding with the study of Elbaih et al., who reported that the incidence of missed injuries was 9.0% after ATLS guideline application. Therefore, the STEPs course may be considered at the same level of ATLS training skills programs in dealing with trauma for decreasing the missed injury cases.

First, there may be untrained senior EC physicians who newly joined the EC and have not attended the STEPs course, which may result in an increased incidence of missed injuries. Second, for the elimination of bias owing to differences in personal skills and years of experience, the redistribution of the few staff available needs to be designed to address the problem. In particular, all residents and assistant lecturers should attend the STEPs course. Third, the STEPs course needs attendance for 4 days by all residents and assistant lecturers. Trauma patients should be transferred to other trauma centers to allow all EC physicians the chance to attend the STEPs course, with the end result being a standardized approach for trauma. Finally, in our resource-limited setting, in which staff shortage is a challenging problem, the redistribution of the few available staff should be designed to address the problem for decreased incidence of missed injuries.

Conclusion

The implementation of the STEPs course decreased the incidence of missed injuries in polytrauma patients. Thus, the STEPs course may be considered at the same level of other advanced trauma courses as a training skills program or possibly better in dealing with trauma patients. Repetition of the course by physicians should be mandatory for the prevention of missed injuries. Therefore, the validation of the STEPs course certificate should not be for more than two years to help decrease the incidence of missed injuries, especially in low-income countries and low-resource settings.

Competing interests

The authors declared no competing interests.

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Dissemination of results

Results of this study were presented locally at the Emergency Centre scientific day with staff members at Suez Canal University.

Authors' contribution

Authors contributed as follows to the conception or design of the work, the acquisition, analysis, or interpretation of data for the work; and drafting the work or revising it critically for important intellectual content: AHE contributed 30%; MTI and MoE-S contributed 20%; and HME, MaE-S and JMH 10% each. All authors approved the version to be published and agreed to be accountable for all aspects of the work.

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