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Evaluation of the predictive value of thorax trauma severity score (TTSS) in thoracic-traumatized patients

Mohamed Reda Zahran[1*], Amr Abd El Monem Abd Elwahab[2], Mohamed Mahmoud Abo El Nasr[3] and Mohamed Ahmed El Heniedy[4]

Abstract

Background: Thorax trauma severity score (TTSS) combines patient-related parameters with the anatomical and physiological parameters, and it can be easily calculated in the emergency room. The validity of this score in the Egyptian population has not been tested; therefore, the objective of this study was to evaluate the prognostic role of TTSS to predict the outcome of thoracic trauma in the Egyptian patients in two centers.

Results: The study included 284 male patients (94.7%) with a mean age of 41 years. Fifty-six patients (18.7%) had conservative management, 216 had morbidity (72%), and 28 patients died (9.3%). One hundred forty-eight patients (49.3%) had a thoracostomy tube, and thoracotomy was required in 4 patients (1.3%). Respiratory rate above 20 cycles/min at admission was associated with mortality (n = 28 (9.3%); $p < 0.001$). One hundred thirty-six patients had TTSS between 0 and 5 points; 56 of them were discharged and 80 of them were admitted to the inpatient ward with a good prognosis. Twenty-four patients had TTSS between 21 and 25 points; all the 24 patients had a fatal prognosis. A cut-off value of 7 points or more of TTSS was 100% sensitive and 97.73% specific to poor and fatal prognosis, and it was significantly associated with acute respiratory distress syndrome and the need for mechanical ventilation (n = 64; $p < 0.001$; AUC = 0.998).

Conclusion: The outcome of thoracic trauma patients could be predicted based on the thorax trauma severity score. A score of 7 points or above was associated with increased morbidity, and a score of 20 points or above predicted a fatal prognosis and prolonged mechanical ventilation.

Keywords: Thorax trauma severity score, Thoracic trauma, Outcome prediction

Background

The outcome of thoracic trauma is variable and is affected by the interaction between several demographics and anatomical factors [1, 2]. Although most of the life-threatening injuries can be managed with minor surgical interventions [3, 4], the reported mortality in thorax trauma ranged from 15 to 25% [5]. Additionally, predictors of morbidity and mortality after thoracic trauma vary widely in the literature, and the associated extra-thoracic injuries have a significant role in determining the outcome s[4].

Several scores were developed to predict the outcomes of thoracic injuries such as the trauma and injury severity score, which is used in poly-traumatized patients, and Wagner score for the pulmonary contusion [6]. Trauma and injury severity score may underestimate thoracic injuries, in addition to its difficulty in the calculation [7]. In 2000, Pape and coworkers developed a new score, thorax trauma severity score (TTSS), that combined the patient-related parameters with the anatomical and physiological parameters [8]. TTSS is composed of five parameters; age, PaO2/FiO2, pleural injuries, lung contusion, and rib fractures, and the score ranges from 0 to 25 points.

The validity of this score in the Egyptian population has not been evaluated; therefore, the objective of this

* Correspondence: medozamzam1@gmail.com
[1]Emergency Medicine, Faculty of Medicine, Tanta University, Mansoura, Egypt
Full list of author information is available at the end of the article

study was to assess the prognostic role of TTSS to predict the outcome of thoracic trauma in the Egyptian patients in two centers.

Methods

Patients and design

We conducted a prospective cohort study on 300 chest trauma patients in two emergency departments during the period from May 2018 through April 2019. We included adult patients aged 18 years or above. Patients with a burn, chronic respiratory diseases, pregnancy, malignancy, end-organ failure, and patients with associated mediastinal, severe abdominal, pelvic injuries, or brain injuries with Glasgow Coma Score (GCS) below 13 were excluded.

Ethical considerations

The study was approved by the local Ethical Committee of the participating centers, and the need to obtain informed consent was waived.

Trauma management

We managed the patients according to the Advanced Trauma Life Support (ATLS) guidelines. All patients had routine laboratory investigations including random blood glucose, complete blood count, and arterial blood gases (ABG). We performed a chest X-ray, computed tomography scan, electrocardiogram for all patients, and echocardiography if a cardiac injury was suspected.

Scoring system

TTSS (thorax trauma severity score) was used to evaluate the severity of the trauma, and its components are shown in Table 1. The outcome was recorded along with the patient's data and the scoring system. The prognosis of the patients was classified into the following categories: normal; which included discharged patients, good; which included patients who were admitted to inpatient ward up to 7 days, or patients with pneumothorax, or hemothorax who were managed with simple thoracostomy, fair; which included patients who were admitted to inpatient ward more than 7 days, patients with pneumothorax with persistent air leak, patients with hemothorax who needed open thoracotomy, or patients who were admitted to ICU but did not require mechanical ventilation, poor; which included patients who were admitted to ICU and needed mechanical ventilation, fatal; which included patients who died. Morbidity was presented with a good, fair, and poor prognosis, and mortality with the fatal prognosis.

Statistical analysis

Quantitative data were presented as mean and standard deviation (SD) and qualitative data as frequencies and percentages. The chi-square or Fisher exact tests were used to compare qualitative data. A probability value of less than 0.05 was considered statistically significant. Regression analysis was used to explore the relation between TTSS, and the duration of mechanical ventilation and ICU stay. The receiver operator curve (ROC) was used to evaluate the statistical significance of sensitivity and specificity and to choose suitable cut-off points to make decisions. SPSS (Statistical Package for Social Science; SPSS for IBM, USA) version 23 for Microsoft Windows was used to perform the analysis.

Results

Patients' data

The study included 284 male patients (94.7%), and 68 of the patients (22.7%) were below 30 years, 108 patients (36.0%) were between 30 and 41 years, 60 patients (20.0%) were between 42 and 54 years, 44 patients (14.7%) were between 55 and 70 years, 20 patients (6.7%) were above 70 years, the mean age was 41 years and the standard of deviation was ± 14. Ninety-six patients (32.0%) had penetrating trauma, and 204 patients had blunt trauma (68.0%) including, fall from height in 40 patients (13.33%), road traffic accident (RTA) in 52 patients (17.33%), and crush injury in 4 patients (1.33%).

Respiratory rate was associated with patients' outcomes; all fatalities had a respiratory rate above 20 cycle/min ($p < 0.001$). All patients with heart rate (HR) below 100 beats per minute were discharged, and HR above 100 beats per minute was associated with an increase in morbidity and mortality ($p < 0.001$) (Table 2).

Table 1 Items of the thorax trauma severity score (TTSS) [8]

Grade	PaO2/FiO2	Rib fractures	Lung contusion	Pleura	Age	Points
0	> 400	0	No	No	< 30	0
I	300–400	1–3	Unilobar unilateral	Pneumothorax	30–41	1
II	200–300	3–6 (will use 4 to 6) unilateral	Unilobar bilateral or bilobar unilateral	Hemothorax or hemo/pneumothorax unilateral	42–54	2
III	150–200	> 3 bilateral	Bilateral < 2 lobes	Hemothorax or hemo/pneumothorax bilateral	55–70	3
IV	< 150	Flail chest	Bilateral ≥ 2 lobes	Tension pneumothorax	> 70	5

Notes: (a) For calculation of the total score, all categories are summed. (b) A minimum value is of 0 points and a maximum value is of 25 points

Table 2 The effect of vital signs on patients' outcomes

Vital signs		Discharge N = 56	Morbidity N = 216	Mortality N = 28	p value
SBP					<0.001
	<90	0 (0.00%)	48 (16.00%)	20 (6.70%)	
	90–109	4 (1.3%)	44 (14.70%)	0 (0.00%)	
	>110	52 (17.3%)	124 (41.30%)	8 (2.70%)	
RR					<0.001
	1219	52 (17.30%)	44 (14.70%)	0 (0.00%)	
	20–29	4 (1.30%)	148 (49.30%)	0 (0.00%)	
	>30	0 (0.00%)	24 (8.00%)	28 (9.30%)	
HR					<0.001
	<100	56 (18.70%)	60 (20.00%)	0 (0.00%)	
	100–120	0 (0.00%)	128 (42.70%)	12 (4.00%)	
	120–140	0 (0.00%)	28 (9.30%)	12 (4.00%)	
	>140	0 (0.00%)	0 (0.00%)	4 (1.30%)	

(Categorical variables are presented as number and percentage)
HR: Heart rate, *RR*: respiratory rate, *SBP*: systolic blood pressure

Fifty-six patients (18.7%) were discharged with conservative management, 216 patients had morbidity (72%), and 28 patients died (9.3%); all of them had life-threatening thoracic injuries (Table 3). One hundred forty-eight patients (49.3%) had closed thoracostomy or observation in the inpatient ward, 24 patients (8%) needed observation ICU, and 44 patients (14.7%) needed mechanical ventilation. Thoracotomy was required in 4 patients (1.3%).

TTSS and patients' outcome

One hundred thirty-six patients had TTSS between 0 and 5 points; 56 of them were discharged and 80 of them were admitted to the inpatient ward with a good prognosis.

Ninety-two patients had TTSS between 6 and 10 points; 60 of them were admitted to inpatient ward (40 patients had a good prognosis 20 patients had a fair prognosis), and 32 patients were admitted to ICU (16 patients had a fair prognosis and16 patients had a poor prognosis).

Twenty-four patients had TTSS between 11 and 15 points; eight of them were admitted to the inpatient ward and had a fair prognosis, and 16 patients were admitted to ICU (8 patients had a fair prognosis and eight patients had a poor prognosis).

Twenty-four patients had TTSS between 16 and 20 points; 20 of them were admitted to ICU and had a poor prognosis and four patients died after 34–38 days of ICU stay.

Twenty-four patients had TTSS between 21 and 25 points; 12 of them died in the emergency room (ER) and 12 died after 30–40 days in the ICU. All the 24 patients had a fatal prognosis.

TTSS of 7 points or more was associated with developing acute respiratory distress syndrome (ARDS) and the need for mechanical ventilation (n = 64). Increased TTSS was associated with increased duration of mechanical ventilation and prolonged ICU stay (p < 0.001) (Figs. 1 and 2). A cut-off point of 7 or above of TTSS had a 100% sensitivity to fair, poor, and fatal prognosis, and 97.73 % specificity to good and normal prognosis, with 96.88% positive predictive value and 100.00 % negative predictive value. The area under the curve was 0.998 (Fig. 3).

Discussion

Our study showed that the TTSS value of 7 points or above points had 100% sensitivity and 97.73 % specificity to morbidity and mortality of patients of isolated thoracic trauma after exclusion of associated severe extra-thoracic injuries. This result agrees with Elbaih and coworkers, who found that the TTSS value of 7 or above was 100% sensitive and 100% specific to poor prognosis [9]. Similarly, Elnaby and associates found that the TTSS value of 8 or above had a sensitivity of 92.3% and a specificity of 100% in the prediction of poor outcome and mortality [10]. In another study, TTSS of 8 points had a sensitivity of 80% and a specificity of 94% to predict complications and death [11].

In our study, the area under the curve was 0.998 showing that TTSS has a strong predictive value for morbidity and mortality. In a study by Hildebrand and associates, they found that TTSS had the best predictive value in comparison to CT-dependent Wagner score for pulmonary contusion and CT-independent scoring system [12]. On the other hand, Moon and associates found that thorax and trauma injury severity score (TRISS) was superior to TTSS in predicting the mortality of severe thoracic trauma [13]. However, the study was retrospective with possible selection biases.

Mortality occurred in 28 patients (9.3%) and had TTSS ranging from 20 to 23. Subhani and coworkers had 9.8% mortality, and high TTSS was associated with increased mortality. [14] We noticed that bilateral lung contusion more than two lobes had a significant effect on mortality, which is consistent with other studies [14].

Flail chest was associated with a mortality rate of 66% in our study. In another study, the flail chest had a mortality of 36% [14].

We found that 76 patients (25.3%) had lung contusion injuries in the absence of thoracic bony fractures. Shorr and colleagues declared that severe parenchymal lung injuries could be present even if thoracic bony injuries are absent [15]. The majority of rib fracture injuries were managed with conservative treatment. Mechanical ventilation was not indicated except when signs of respiratory failure were developed [16, 17].

Table 3 Patients' outcome distributed according to thorax trauma severity score (TTSS)

TTSS parameters		Prognosis of patients			*p* value
		Discharge	Morbidity	Mortality	
		N = 56	*N* = 216	*N* = 28	
Pleural involvement	No	56(18.70%)	20(6.70%)	0(0.00%)	< 0.001
	Pneumothorax	0(0.00%)	76(25.30%)	0(0.00%)	
	Hemothorax or hemo/pneumothorax unilateral	0(0.00%)	84(28.00%)	0(0.00%)	
	Hemothorax or hemo/pneumothorax bilateral	0(0.00%)	32(10.70%)	8(2.70%)	
	Tension pneumothorax	0(0.00%)	4(0.00%)	20(6.70%)	
Lung contusion	No	56(18.70%)	100(33.30%)	0(0.00%)	< 0.001
	Unilobar unilateral	0(0.00%)	32(10.70%)	0(0.00%)	
	Unilobar bilateral or bilobar unilateral	0(0.00%)	28(9.30%)	0(0.00%)	
	Bilateral < 2 lobes	0(0.00%)	20(6.70%)	0(0.00%)	
	Bilateral > 2 lobes	0(0.00%)	36(12.00%)	28(9.30%)	
Rib fractures	No	56(18.70%)	144(48.00%)	0(0.00%)	< 0.001
	1–3 Fracture ribs	0(0.00%)	28(9.30%)	4(1.30%)	
	3–6 Fracture ribs	0(0.00%)	28(9.30%)	0(0.00%)	
	> 3 Bilateral fracture ribs	0(0.00%)	8(2.70%)	8(2.70%)	
	Flail chest	0(0.00%)	8(2.70%)	16(5.30%)	
PaO2/FiO2	> 400	56(18.70%)	24(8.00%)	0(0.00%)	< 0.001
	300–400	0(0.00%)	80(26.70%)	0(0.00%)	
	200–300	0(0.00%)	60(20.00%)	0(0.00%)	
	150–200	0(0.00%)	28(9.30%)	0(0.00%)	
	< 150	0(0.00%)	24(8.00%)	28(9.30%)	

(Categorical variables are presented as number and percentage)

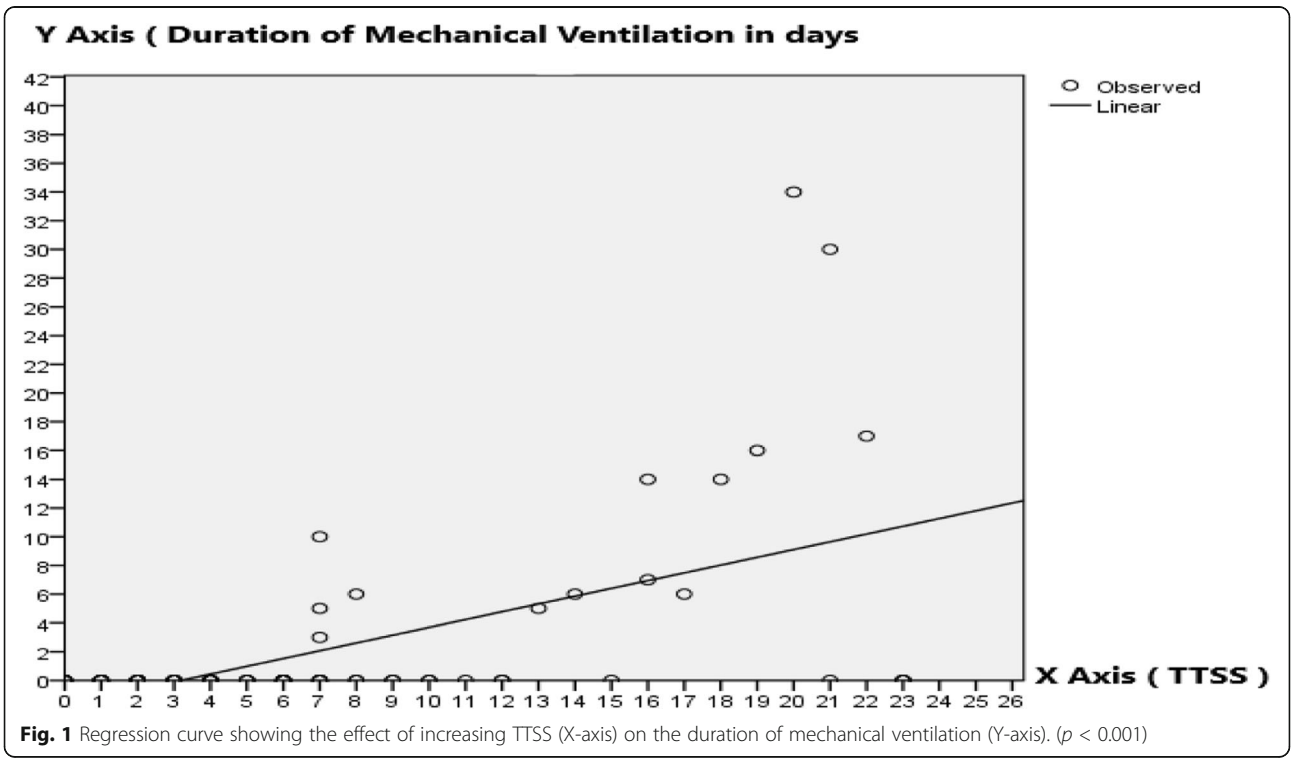

Fig. 1 Regression curve showing the effect of increasing TTSS (X-axis) on the duration of mechanical ventilation (Y-axis). ($p < 0.001$)

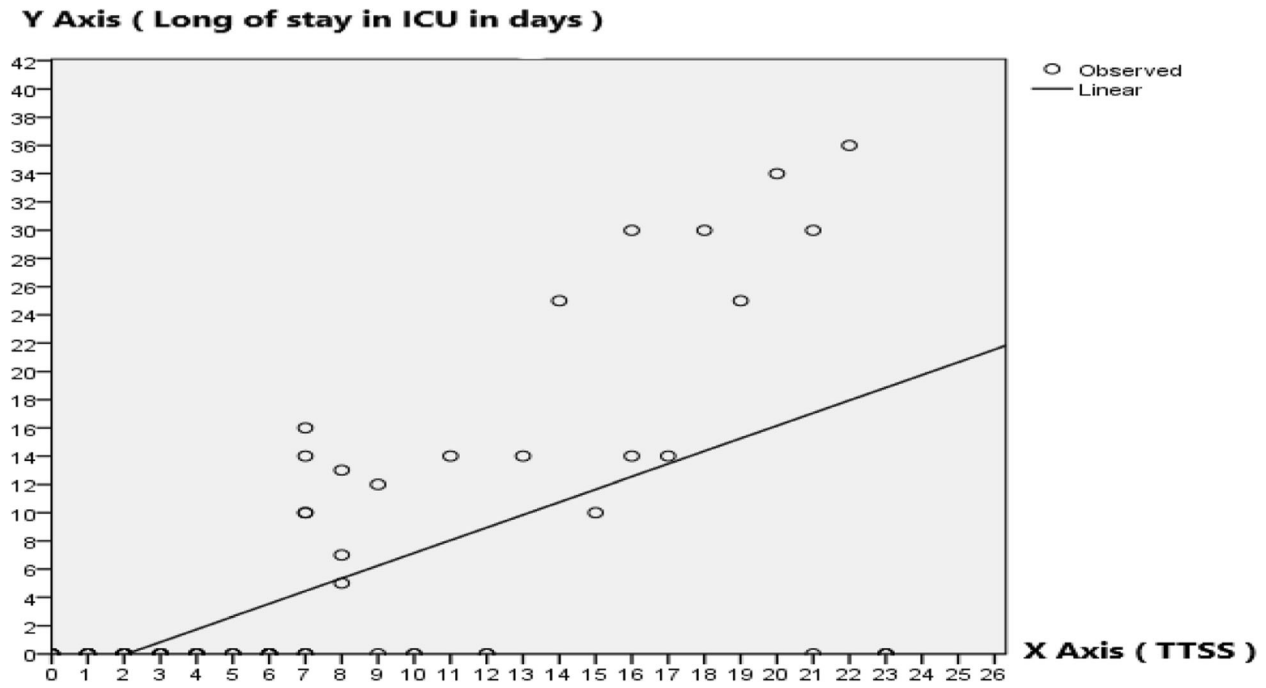

Fig. 2 Regression curve showing the effect of increasing TTSS (X-axis) on the duration of ICU stay (Y-axis). ($p < 0.001$)

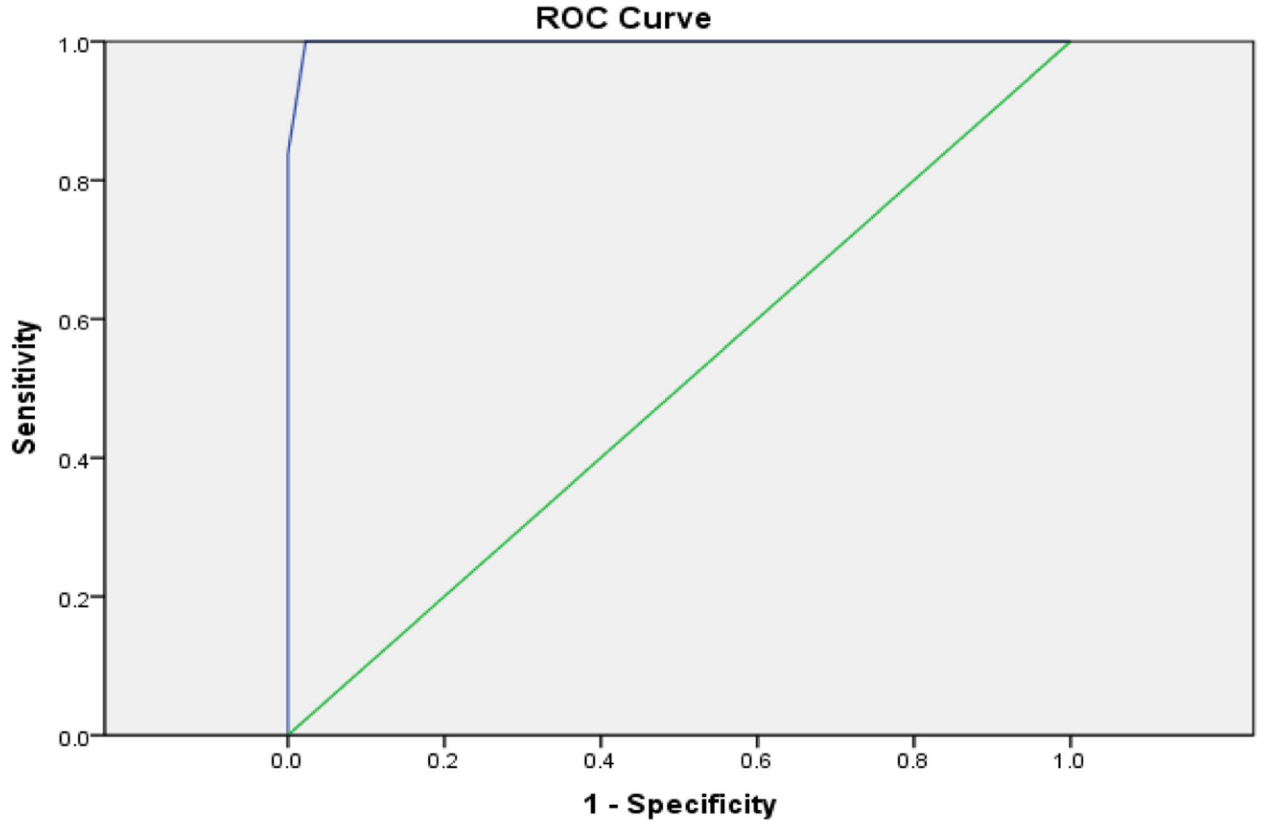

Fig. 3 The receiver operator curve (ROC) of the predictability of thorax trauma severity score (TTSS) with area under the curve equals 0.998

In our study, most patients were managed with simple procedures without any major complications, and 56 patients (18.7%) were discharged with conservative treatment. Four patients had thoracotomy, and this trend in managing chest trauma can be explained by the advancement of the imaging systems, new therapeutics, and minimally invasive procedures. All of those had contributed in decreasing the morbidity and mortality of thoracic trauma injuries [18].

We noticed in our study that low TTSS values were associated with a good prognosis, and the high TTSS values were associated with higher morbidity and mortality. Correspondingly, Subhani and colleagues stated that low TTSS values were associated with a normal and good prognosis, and high TTSS values were associated with a good, fair, poor, and fatal prognosis [14].

We found that with increasing TTSS above 7, there was an increased probability of mechanical ventilation, and duration of mechanical ventilation and ICU stay. This study comes in agreement with Balkan and associates, who found that there was an association between morbidity, mortality, and the need for mechanical ventilation [19].

TTSS, with a cut-off value of 7 points or above, was associated with ARDS, which is consistent with other studies [20, 21].

Limitation of the study

The age is a major component of the score, although it was not significant, which affected the sensitivity and specificity of the score.

Flail chest, either a small or large-sized segment in chest fractures parameter in TTSS has a score of 5 points; however, small-sized flail segments can be managed with conservative treatment. Fracture of the first or second ribs is an indicator of severe trauma; despite that, they take 1 point on TTSS.

Conclusion

The outcome of thoracic trauma patients could be predicted based on the thorax trauma severity score.

A score of 7 points or above was associated with increased morbidity, and patients require close monitoring.

A score of 20 points or above predicted a fatal prognosis and prolonged mechanical ventilation.

Abbreviations

ARDS: Acute respiratory distress syndrome; ER: Emergency Room; HR: Heart rate; ICU: Intensive Care Unit; RR: Respiratory rate; RTA: Road traffic accident; SBP: Systolic blood pressure; TRISS: Trauma and Injury Score; TTSS: Thorax trauma severity score

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Authors' contributions

MZ participitated in collection of data and writing the thesis. AA was the supervisor participated in statistical analysis, writing the thesis and pioneering the ideas. MMA and MAE participated in writing and guiding the work . All authors have read and approved the manuscript.

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Availability of data and materials

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Ethics approval and consent to participate

The present prospective study has been approved by the local ethical committee (Quality
Management Unit) in the Faculty of Medicine in Tanta University. The need to obtain informed consent was waived by the local ethical committee. The reference number is not applicable and not available.

Consent for publication

A written consent was obtained from each patient participitated in the medical research.

Competing interests

The authors declare that they have no competing interests.

Author details

[1]Emergency Medicine, Faculty of Medicine, Tanta University, Mansoura, Egypt. [2]Cardiothoracic Surgery, Faculty of Medicine, Tanta University, Tanta, Egypt. [3]Cardiothoracic Surgery, Faculty of Medicine, Tanta University, Tanta, Egypt. [4]Emergency Medicine Department, Faculty of Medicine, Tanta University, Tanta, Egypt.

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