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Evaluation of Trauma Severity Scores in Electric Scooter Related Injuries

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Abstract

Aim: Our study aimed to identify injuries related to electric scooters (e-scooters) in the emergency department (ED) and to compare trauma severity scores.

Materials and Methods: This prospective, single-center study was conducted during the 3-month summer period between June 1 and August 31, 2023, on adult and pediatric patients who presented to the ED with e-scooter-related injuries. ROC analyses were performed for the injury severity score (ISS), revised trauma score (RTS), and trauma and injury severity score (TRISS).

Results: A total of 106 patients were included, with a mean age of 21.5 years (interquartile range: 15–39.5), and 69.8% (n=74) were male. The three most commonly injured areas in patients admitted to the ED with e-scooter injuries were the head (50.9%, n=54), knee (34.9%, n=37), and forearm-elbow (26.4%, n=28). The median ISS of patients admitted to the intensive care unit was higher than that of patients admitted to the ward or discharged (NISS: 18 vs. 2), whereas the median RTS and TRISS values were lower (RTS: 7.64 vs. 7.84; TRISS: 4.39 vs. 5.72). The median ISS of deceased patients was higher than that of surviving patients (ISS: 29 vs. 2), while the RTS and TRISS values were lower (RTS: 7.11 vs. 7.84; TRISS: 3.48 vs. 5.72). The TRISS (area under the curve =0.991) had the highest discriminatory ability in predicting mortality ($p<0.001$). When the TRISS was ≤4.47, the sensitivity for predicting mortality was 100%, specificity 96.97%, positive predictive value 70%, negative predictive value 100%, positive likelihood ratio 33, and negative likelihood ratio 0.0.

Conclusion: E-scooter-related injuries were common among young people and males. The most frequent injury sites were the head, knee, and forearm–elbow region. The TRISS was the most successful score in predicting mortality in e-scooter-related injuries.

Keywords: E-scooter, injury severity score, revised trauma score, trauma and injury severity score

Introduction

Due to advantages such as fast transportation, affordability, compactness, and portability, the use of electric scooters (e-scooters) has increased in recent years, both worldwide and in Türkiye. The convenience provided by e-scooters has also brought with it some safety issues (1). The rapid increase in the use of e-scooters worldwide has led to a increase in injuries. Various studies have shown that orthopedic injuries related to e-scooter accidents often occur in the head and extremities and that they are high-energy, serious injuries. Failure to use helmets and protective equipment leads to serious e-scooter-related injuries (2). In Türkiye, individuals over the age of 15 can use e-scooters, and there is no requirement to wear protective gear or have a driver's license when using them. In Türkiye, the speed limit for e-scooters is set at 25 km/h, and riding on sidewalks and carrying more than one person is prohibited (3). In the US, the population-adjusted incidence of e-scooter-related injuries rose from 1.53 per 100,000 people in 2014 to 9.22 per 100,000 people in 2019, with the head being the the most common site of injury (4,5).

Traumatic injuries are a significant cause of morbidity and mortality, particularly among young adults and adolescents. The varying mortality rates reported at different trauma centers highlight the potential for differing trauma severity and the

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importance of scoring traumatic injuries (6). Various scoring systems exist, such as the injury severity score (ISS), revised trauma score (RTS), and trauma injury and severity score (TRISS), based on the anatomical location and characteristics of injuries or specific physiological parameters. The RTS is calculated using parameters such as the glasgow coma scale (GCS), systolic blood pressure (SBP), and respiratory rate. In contrast, the ISS is calculated by summing the squares of the highest abbreviated injury score (AIS) values in the three most severely injured body regions. The TRISS is computed using the ISS and RTS scores. These scoring systems have their strengths and weaknesses in the emergency department. Simple models offer ease of use, while more complex models offer higher accuracy (7).

Our study aimed to identify e-scooter-related injuries in the emergency department of University of Health Sciences Türkiye, Kayseri City Hospital, a tertiary care hospital, and to compare trauma severity scores.

Materials and Methods

Type of Research and Ethics

Our study was designed as a descriptive, prospective, single-center study. The study was conducted at the Emergency Medicine Clinic of University of Health Sciences Türkiye, Kayseri City Training and Research Hospital after obtaining approval from the Clinical Research Ethics Committee of the same institution (decision number: 890, date: 22.08.2023). The study was conducted in accordance with the Helsinki Declaration.

Study Design and Population

Our study was conducted on adult and pediatric patients with e-scooter-related injuries who visited the emergency department during the 3-month summer period between June 1, 2023, and August 31, 2023. Written consent was obtained from all patients or their families. All patients were informed about the study, and consent was obtained from the patients themselves and their parents or guardians.

Of the 122 eligible patients, 106 were included in the study. A total of 16 patients were excluded, including 12 patients who did not give consent and four patients who were brought in with out-of-hospital cardiac arrest (Figure 1).

Statistical Analysis

The obtained data were statistically analyzed using the IBM SPSS 27 (Statistical Package for Social Sciences). The Kolmogorov-Smirnov or Shapiro-Wilk test was used to determine whether the distributions of the variables were normal. Data for continuous variables were presented as mean, standard deviation, or median and interquartile range (IQR) or minimum-maximum values, depending on whether they followed a normal distribution. Categorical variables were presented as percentages and frequencies. Since the variables did not follow a normal distribution in comparisons between two groups, the Mann-Whitney U test was used. ROC analyses were performed for the ISS, RTS, and TRISS. In addition, the ROC curves of these parameters were compared. Descriptive statistics such as area under the curve (AUC) (ROC curve), sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), positive likelihood ratio, negative likelihood ratio, and 95% confidence interval were provided. Statistical significance was set at $p<0.05$.

Trauma Score Formulas

1. ISS: Calculated based on the three most severely injured body regions according to the AIS (6).

$ISS= X^2+Y^2+Z^2$

2. RTS: RTS= 0.9368 (GCSc) + 0.7326 (SBPc) + 0.2908 (coded respiratory rate) (7).

3. TRISS: $b = b^0 + b^1(RTS) + b^2(ISS) + b^3$(age index) (8-10).

Results

The average age of patients was 21.5 (IQR: 15-39.5, min: 1, max: 81) years, and 69.8% (n=74) were male and 30.2% (n=32) were female. In addition, 33% (n=35) of patients were under the age of 18. Fifteen patients (14.2%) were under 10 years of age and

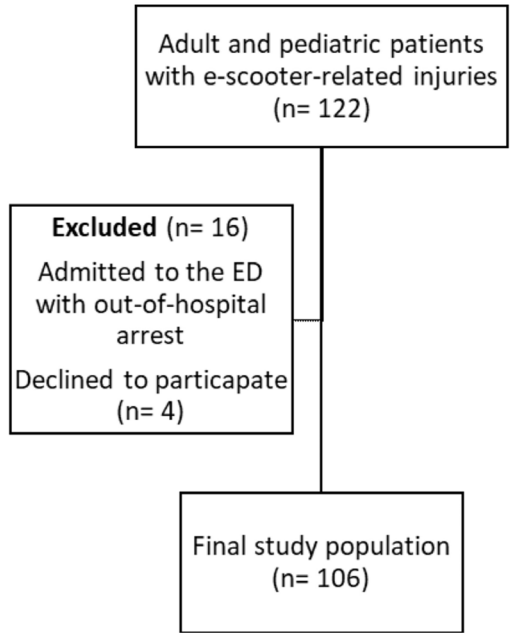

Figure 1. Flow chart of patients included in the study
ED: Emergency department

had ridden the e-scooter with someone older than themselves. One patient was one year old. None of the patients was wearing helmets or protective gear. The three most commonly injured areas among patients admitted to the emergency department due to e-scooter injuries were the head (50.9%, n=54), knee (34.9%, n=37), and forearm and elbow regions (26.4%, n=28) (Figure 2). While 12.3% (n=13) of the patients were admitted to the intensive care unit (ICU), 87.7% (n=93) were admitted to the ward. 6.6% (n=7) of the patients died; two died in the emergency department and five in the hospital.

Statistically significant differences were found among ISS, RTS, and TRISS scores and ICU admission (p-values: <0.001, <0.003, and <0.001, respectively). The median ISS scores of patients admitted to the ICU were higher than those of patients admitted to the ward or discharged (NISS: 18 vs. 2), while the median RTS and TRISS scores were lower (RTS: 7.64 vs. 7.84 and TRISS: 4.39 vs. 5.72) (Table 1).

Statistically significant differences were found between ISS, RTS, TRISS scores, and their relationship with mortality (p-values <0.001). The median ISS scores of deceased patients were higher than those of surviving patients (ISS: 29 vs. 2), while the median RTS and TRISS scores were lower (RTS: 7.11 vs. 7.84; TRISS: 3.48 vs. 5.72) (Table 1).

According to the results of the ROC analysis of continuous measurements in terms of mortality, the ability of ISS, RTS, and TRISS scores to predict mortality was found to be statistically significant, (p-values<0.001). Accordingly, patients with ISS >13, RTS ≤7.55, and TRISS ≤4.47 were found to have a higher probability of death. The TRISS score (AUC=0.991) had the highest discriminatory ability in predicting mortality (p<0.001). When the TRISS score was ≤4.47, the sensitivity for predicting mortality was 100%, specificity was 96.97%, PPV was 70%, NPV was 100%, positive likelihood ratio was 33, and negative likelihood ratio was 0.0. ROC analyses and curves for predicting mortality using the scores are shown in Table 2 and Figure 3. Additionally, in the pairwise comparisons of ROC curves for mortality, no statistically significant difference was found in the AUC values of the measurements for the ISS, RTS, and TRISS scores (p-values were p=0.119 for ISS vs. RTS, p=0.316 for ISS vs. TRISS, and p=0.085 for RTS vs. TRISS).

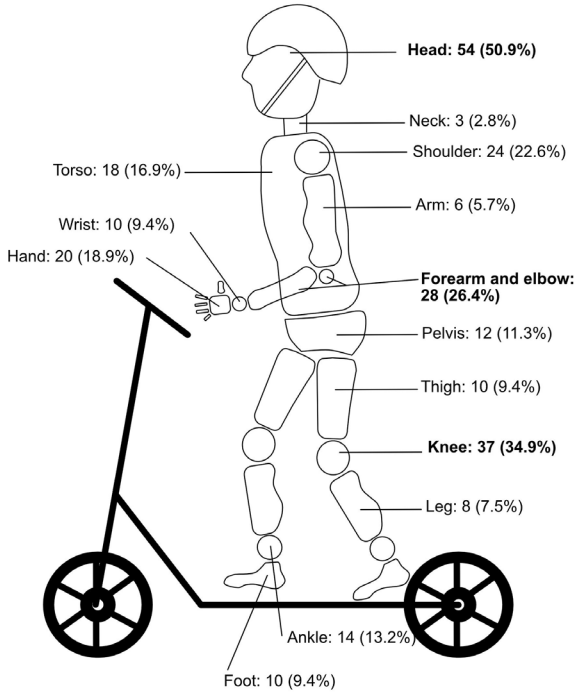

Figure 2. Distribution of injury locations among patients with e-scooter-related injuries

E-scooter: Electric scooter

Table 1. Comparison of variables in terms of ICU admission and mortality

Variable	Total (n=106)	Non-ICU (n=93)	ICU (n=13)	p	Survive (n=99)	Death (n=7)	p
Age, years	21.5 (15-39.5)	21 (16-34.5)	41 (9-64.5)	0.234	22 (16–39)	17 (11-57)	0.775
Male, %	74 (69.8)	66 (71)	8 (61.5)	0.526*	70 (70.7)	4 (57.1)	0.429*
Heart rate, beats/min	90 (82.8-99)	90 (82.5-98.5)	88 (82.5-107.5)	0.889	90 (82-98)	86 (84-113)	0.524
SBP, mmHg	120 (110-131)	120 (110-130)	132 (122.5-154)	0.019	120 (110-130)	136 (86-100)	0.275
DBP, mmHg	79.5 (70-82)	78 (70-82)	82 (74.5-88.5)	0.079	80 (70-82)	79 (64-112)	0.744
SpO^2, %	99 (97.8-99)	99 (98-99)	99 (95.5-100)	0.941	99 (98-99)	99 (94-100)	0.854
ISS, median (IQR)	2 (2-9)	2 (1-5)	18 (17-27.5)	<0.001	2 (1-5)	29 (17-41)	<0.001
RTS, median (IQR)	7.84 (7.84-7.84)	7.84 (7.84-7.84)	7.64 (7.33-7.84)	0.003	7.84 (7.84-7.84)	7.11 (6.61-7.84)	<0.001
TRISS, median (IQR)	5.72 (5.14-5.81)	5.72 (5.47-5.80)	4.39 (3.29-5.26)	<0.001	5.72 (5.47-5.80)	3.48 (2.23-3.86)	<0.001

*Fisher's exact test was used, and other p-values were calculated using the Mann-Whitney U test.
ICU: Intensive care unit, IQR: Interquartile range, SBP: Systolic blood pressure, DBP: Diastolic blood pressure, SpO^2: Peripheral capillary oxygen saturation, ISS: Injury severity score, RTS: Revised trauma score, TRISS: Trauma and injury severity score

Table 2. ROC analysis results for mortality prediction								
	AUC (p value)	Cut-off	Sensitivity (95% CI)	Specificity (95% CI)	LR+	LR−	PPV	NPV
Mortality - ISS	0.978 (<0.001)	>13	100 (59-100)	91.9 (84.7-96.4)	12.4	0.0	46.7	100
Mortality - RTS	0.837 (<0.001)	≤7.55	71.43 (29-96.3)	95.96 (90-98.9)	17.68	0.30	55.6	97.9
Mortality-TRISS	0.991 (<0.001)	≤4.47	100 (59-100)	96.97 (91.4-99.4)	33	0.0	70	100

AUC: Area under the curve, CI: Confidence interval, LR+: Positive likelihood ratio, LR−: Negative likelihood ratio, PPV: Positive predictive value, NPV: Negative predictive value, ISS: Injury severity score, RTS: Revised trauma score, RTS: Revised trauma score, TRISS: Trauma and injury severity score

Discussion

Demographic studies of e-scooter-related injuries have shown that patients are in their thirties and two-thirds are male (11–13). In our study, slightly more than two-thirds of patients were male, and the median age was 21.5 years, which was lower than in other studies.

E-scooter-related injuries are more serious because people do not use protective gear. Bloom et al. (14) looked at 248 patients with e-scooter-related injuries and found that only 3% wore helmets. In a study, it was reported that the most common reasons for motorcycle riders not to use a helmet were the weight of the helmet, heat and suffocation, neck pain, and the restriction of head and neck movements (15). In our study, none of the patients who came in with e-scooter injuries wore helmets. This result shows the importance of monitoring e-scooter users and the necessity of using protective equipment.

Störmann et al. (12) found that the upper and lower extremities were most commonly injured in patients presenting with e-scooter-related injuries, while Clough et al. (16) reported that both head and extremity injuries were most common. In our study, the most common injuries were to the head, knee, and forearm, elbow region. The importance of helmet, knee pad, and elbow pad use was emphasized in our study.

Studies on multiple-trauma patients have investigated the predictive value of trauma scores, frequently comparing ISS, RTS, and TRISS scores (7,9,17,18). A study conducted in France showed that e-scooter injuries are similarly severe as those resulting from bicycles or motorcycles (19). In a recent study involving 426 patients with multiple trauma, where ISS and RTS scores were also examined, the TRISS score was found to have the best performance in determining mortality (AUC: 0.93, sensitivity 97.1%, and specificity 76.7%) (20). Similarly, in our study, the TRISS score (AUC=0.991) had the highest discriminatory ability in predicting mortality, with a sensitivity of 100% and a specificity of 97%. In the study by Efeoglu Sacak et al. (21), the AUC value of the RTS score in predicting mortality in multitrauma patients was found to be excellent at 0.92, but in our study, it was good at 0.84.

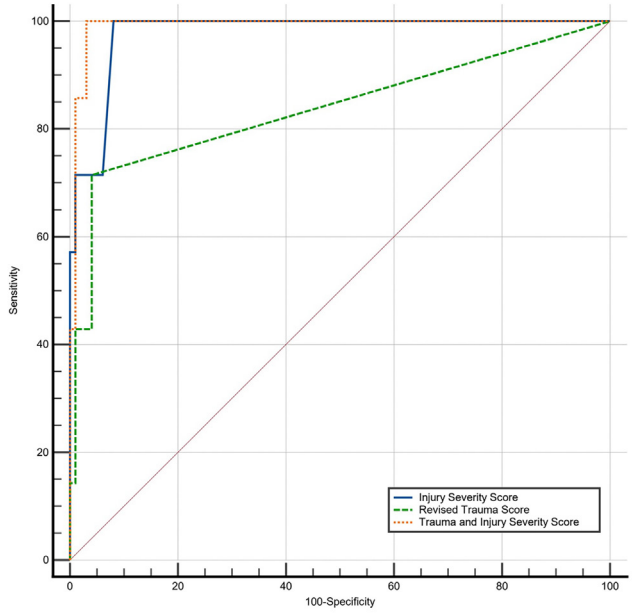

Figure 3. ROC curves of scores in terms of mortality

The main limitation of our study was that it was conducted over a 3-month period and at a single-center. Another limitation was the small number of patients. However, our study in our country that emphasizes the importance of trauma scores in e-scooter injuries and is forward-looking. We believe that more comprehensive studies evaluating trauma scores are needed during this period of increasing e-scooter use.

Study Limitations

The study is limited by its single-center focus and short-term duration. Secondly, the inclusion of patients consecutively while the principal investigator was in the emergency room may have created a sampling bias. Another limitation is the small number of patients. Our study did not evaluate pediatric and adult patients separately. Lastly, patients who visited the emergency department in cardiopulmonary arrest were not included in the study, which may have partially led to a spectrum bias.

Conclusion

In general, injuries related to e-scooters were common among young people and males. The most common injury sites were the head, knee, and forearm-elbow region. TRISS was the most successful score in predicting mortality in injuries related to e-scooters.

Ethics

Ethics Committee Approval: The study was conducted at the Emergency Medicine Clinic of University of Health Sciences Türkiye, Kayseri City Training and Research Hospital after obtaining approval from the Clinical Research Ethics Committee of the same institution (decision number: 890, date: 22.08.2023). The study was conducted in accordance with the Helsinki Declaration.

Informed Consent: Written consent was obtained from all patients or their families.

Footnotes

Author Contributions

Surgical and Medical Practices: R.K.S., Concept: R.K.S., T.Ş., Design: R.K.S., T.Ş., Data Collection or Processing: N.B., Analysis or Interpretation: İ.T., Literature Search: M.B., Writing: R.K.S.

Conflict of Interest: No conflict of interest was declared by the authors.

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