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Does Mechanism of Injury Predict Trauma Center Need?

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Abstract

Objective—To determine the predictive value of the Mechanism of Injury step of the American College of Surgeon's Field Triage Decision Scheme for determining trauma center need.

Methods—EMS providers caring for injured adult patients transported to the regional trauma center in 3 midsized communities over two years were interviewed upon ED arrival. Included was any injured patient, regardless of injury severity. The interview collected patient physiologic condition, apparent anatomic injury, and mechanism of injury. Using the 1999 Scheme, patients who met the physiologic or anatomic steps were excluded. Patients were considered to need a trauma center if they had non-orthopedic surgery within 24 hours, intensive care unit admission, or died prior to hospital discharge. Data were analyzed by calculating positive likelihood ratios (+LR) and 95% confidence intervals (CI) for each mechanism of injury criteria.

Results—11,892 provider interviews were conducted. Of those, 1was excluded because outcome data were not available and 2,408 were excluded because they met the other steps of the Field Triage Decision Scheme. Of the remaining 9,483 cases, 2,363 met one of the mechanism of injury criteria, 204 (9%) of which needed the resources of a trauma center. Criteria with a +LR ≥5 were death of another occupant in the same vehicle (6.8; CI:2.7–16.7), fall >20 ft.(5.2; CI:2.4–11.3), and motor vehicle crash (MVC) extrication >20 minutes (5.0; CI:3.2–8.0). Criteria with a +LR between 2 and <5 were intrusion >12 inches (3.7; CI:2.6–5.3), ejection (3.2; CI:1.3–8.2), and deformity >20 inches (2.3; CI:1.7–3.0). The criteria with a +LR <2 were MVC speed >40 mph (1.9; CI:1.5–2.2), pedestrian/bicyclist struck >5mph (1.2; CI:1.0–1.5), bicyclist/pedestrian thrown or run over (1.2; CI:0.9–1.6), motorcycle crash >20mph (1.1; CI:0.96–1.3), rider separated from motorcycle (1.0; CI:0.9–1.2), and MVC rollover (1.0; CI:0.7–1.5).

Conclusion—Death of another occupant, fall distance, and extrication time were good predictors of trauma center need when a patient did not meet the anatomic or physiologic conditions. Intrusion, ejection, and vehicle deformity were moderate predictors.

Keywords

Wounds and Injury; Triage; Emergency Medical Services; Emergency Medical Technicians

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Introduction

Traumatic injury is the leading cause of death for Americans ages 1 to 44.[1] Compared to the number of patients who sustain traumatic injuries, those who die from their injuries represent just a small proportion (<1%).[2] Injured patients account for approximately 40% of all emergency medical service (EMS) transports.[3] EMS field providers must ensure that the injured patients they transport are taken to the most appropriate hospital that has the necessary resources to manage the patient's injuries. Failure to appropriately triage these patients can result in a significant increase in mortality risk.[4]

The Field Triage Decision Scheme, established by the American College of Surgeon's Committee on Trauma in 1987, has helped guide EMS providers in making appropriate triage decisions for injured patients.[5] These guidelines describe a four-step process for identifying patients with potentially severe traumatic injuries that require treatment at a trauma center, which they defined as a patient with an Injury Severity Score (ISS) greater than 15. Patients who meet the physiologic or anatomic components of the Decision Scheme are identified in the first two steps. Patients who fail to meet the conditions under either of these components are then evaluated using the mechanism of injury component, which evaluates patients for mechanisms that are likely to cause injury even if one is not apparent to the EMS provider.

A literature review of the Decision Scheme and its components demonstrated that little scientific evidence exists to support them, particularly for the mechanism of injury component that is used to guide field triage decisions when the physiologic and anatomic components are not met.[6] In 2006 the Centers for Disease Control and Prevention hosted a National Expert Panel of Field Triage which evaluated the Field Triage Decision Scheme and came to consensus on changes that should be made to update the Scheme.[7] The majority of these changes were to the mechanism of injury criteria, many of which were removed. The objectives of this study were to determine the predictive value of specific mechanisms of injury for determining trauma center need for injured adult patients who do not meet the anatomic or physiologic steps of the Field Triage Scheme. A secondary objective was to identify thresholds for the measurable mechanism of injury criteria (e.g., speed) that are the best predictors of trauma center need.

Methods

A two year prospective observational study was conducted from March 2007 to March 2009 at three large tertiary care hospitals which were also state-designated level 1 regional trauma centers in Milwaukee, Wisconsin; Rochester, New York; and Royal Oak, Michigan. These hospitals were the primary receiving hospitals for their regions and treated numerous injured patients transported by EMS who were not considered to have severe injures as well as those patients who were identified as needing a trauma center. The emergency department (ED) in Wisconsin had approximately 61,500 visits annually, in New York 95,000 visits, and in Michigan 115,000 visits.

To be included in the study, subjects had to be adults (age ≥18 years) presenting to a participating ED with a traumatic mechanism of injury (including the full spectrum of severities from ankle sprain to major trauma) transported by an EMS provider (either by ground ambulance or helicopter) from the scene of their injury. For the purposes of this study, traumatic mechanism of injury included assault (including gunshot and stabbing), motor vehicle crash, motorcycle crash, fall, and pedestrian or bicyclist struck. Subjects were excluded if the patient was transported by means other than a ground or air ambulance, transferred from another receiving facility, or transported by multiple EMS agencies where

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the final providers who accompanied the patient to the ED had not observed the scene of injury.

Study interviewers staffed each of the study EDs seven days a week for a set number of hours. The coverage varied by day and site, and did not include overnight hours. The interviewers identified any patient who met the study inclusion/exclusion criteria and interviewed the EMS provider that was in charge of the patient's care immediately after the EMS provider transferred care of the patient to ED staff. The interviewer reviewed each of the Field Triage Decision Scheme conditions with the EMS provider and asked which (if any) of the conditions the patient met. This included the anatomic and physiologic components of the Decision Scheme as well as specific details regarding the patient's mechanism of injury. The EMS providers were asked to estimate the value for any measureable mechanism of injury criteria (e.g., vehicle speed or intrusion distance). When an interviewer was not present in the ED, a paper version of the interview was available for EMS providers to complete on their own.

When the patient was discharged, a research coordinator reviewed their hospital medical record and obtained outcome information. This information was used to determine in retrospect if the patient needed the resources of a trauma center. In the literature, need for a trauma center has been defined in a variety of ways. In several studies it has been defined as a composite measure of whether or not the patient had urgent non-orthopedic surgery within 24 hours, admission to an intensive care unit (ICU), and/or death prior to hospital discharge.[6] Others have used an ISS greater than 15 as a surrogate for those who need a trauma center.[8] We used both definitions, since there is no consensus definition, but considered the composite measure to be our primary outcome. ISS was calculated based on the patient's ICD-9 discharge codes using ICDMAP-90 software (Tri-Analytics, Inc).[9,10]

The medical record review was conducted by a site research coordinator using a structured data collection instrument. To ensure consistency in the data abstraction the research coordinator and a physician site investigator independently reviewed the same ten charts. The abstraction was reviewed and if there were any discrepancies an additional five charts were reviewed. The research coordinator could not independently review charts until there was 100% agreement on the data abstraction between the research coordinator and the physician site investigator on at least five consecutive charts. The physician was available for questions throughout the study and monthly conference calls were held with all of the investigators and coordinators to discuss data abstraction.

All study data were entered into a research database. To ensure accurate data entry, all forms were verified using a double entry system. Data were analyzed using descriptive statistics including sensitivity, specificity, and positive likelihood ratios, as well as 95% confidence intervals. Patients who met the anatomic or physiologic criteria were excluded from the analysis and each mechanism of injury was analyzed separately. We defined a good predictor as a positive likelihood ratio of 5 or greater, a moderate predictor as a positive likelihood ratio between 2 and 5, and a poor predictor as a positive likelihood ratio less than 2.[11] For measurable mechanisms of injury, ROC curves were examined and tables were generated to assist in finding optimal cut points.

The study was approved by all three institutions' Institutional Review Boards.

Results

During the study period we identified 20,542 patients who met the study's inclusion/exclusion criteria at the three study hospitals. A total of 11,892 (58%) were enrolled in the study and EMS provider interviews were conducted. Eligible patients were not enrolled either because no interviewer was on duty, no interviewer was available to complete the interview before EMS left the ED, or the EMS provider refused to complete the survey. Basic characteristics between the missed and included patients were similar (Table 1). Outcome information for the included patients was available for 11,891 (99.99%) subjects.

Based on the information obtained from EMS provider interviews, 2,408 subjects met the physiologic (1,262) or anatomic (1,146) steps of the 1999 Field Triage Decision Scheme. Therefore, 9,483 subjects were included in the mechanism of injury analysis. Of those, 2,363met one of the mechanism of injury criteria of the Field Triage Decision Scheme. Nine percent of the subjects who met any of the mechanism of injury criteria were found to have actually needed the resources of a trauma center (Table 2). Of the patients who did not meet the mechanism of injury criteria, 4% were found to have needed the resources of a trauma center and would have been under-triaged. When we used an ISS greater than 15 as the definition for trauma center need, 9% of subjects who met the mechanism of injury criteria needed the resources of a trauma center while 6% of patients who did not meet the mechanism of injury criteria needed the resources of a trauma center.

The sensitivity, specificity, and positive likelihood ratios for each of the mechanism of injury criteria in the 1999 Field Triage Decision Scheme for determining trauma center need are shown in Table 3. Death of another occupant, fall distance, and extrication time were found to be good predictors of trauma center need, as defined by a positive likelihood ratio of 5 or greater. Intrusion, ejection, and vehicle deformity were moderate predictors as defined by a positive likelihood ratio between 2 and 5.

When ISS greater than 15 was used as the outcome variable instead of the composite measure the results for the individual mechanism of injury criteria changed (Table 4). However, the mechanism of injury criteria that were considered poor predictors (i.e., a positive likelihood ratio less than 2) remained poor predictors regardless of which outcome was used.

Changing the cut points from the 1999 values might improve the ability of some of the criteria to identify patients who needed a trauma center (Tables 5, 6, 7, 8, 9, 10, 11, and 12). For example, patients whose mechanism was pedestrian or bicyclist struck, a striking vehicle speed of greater than 55 mph (+LR = 30.6) had a higher positive likelihood ratio than a cut point of greater than 5 mph (+LR=1.0). Those who fell from a height of 35 feet or greater (+LR = 12.3) had a higher positive likelihood ratio than greater than 20 feet (+LR = 5.3). These tables might be useful in defining more sensitive or alternatively more specific triage criteria depending on regional trauma system needs and resources.

Discussion

This study found that the mechanism of injury criteria used in the 1999 Field Triage Decision Scheme may not be the most efficient for identifying patients who need the resources of a trauma center. Specifically, 91% of those who met the criteria would have been over-triaged while 4% of those who did not meet the criteria would have been under-triaged. While there are no universally accepted rates for under- and over-triage, the American College of Surgeon’s Resources for Optimal Care of the Injured Patient 2006 suggests a 5% rate of under-triage and a 25% to 50% over-triage rate may be acceptable.[8] A previous study which applied the 2006 Field Triage Decision Scheme to the same data set found that using the physiologic, anatomic, and mechanism of injury criteria resulted in 28% under-triage and 22% over-triage.[12] A separate analysis of the National Trauma Databank found that the anatomic and physiologic steps alone resulted in 51% under-triage and 22%

over-triage.[13] Therefore, including mechanism of injury in the decision scheme clearly improves under-triage.

Under-triage rates should be minimized since under-triage significantly increases mortality by depriving patients of trauma center care.[4] While over-triage has no direct effect on an individual patient's outcome, it can have significant negative effects on the emergency care system, trauma system, and indirect patient effects. Bringing extra patients to the trauma center may unnecessarily contribute to ED crowding and increase hospital turnaround times, while having ambulances by-pass closer non-trauma centers can increase EMS transport times, making the EMS system less efficient for all patients. Ambulances bypassing non-trauma hospitals can have negative economic consequences for those hospitals and threaten their survival, while transport methods used to reduce the time to the trauma center (i.e., helicopter transport and ground transport with emergency lights and sirens) can increase the risk of additional injury[14–16] and cost.

The key difference between this and previous studies of the mechanism of injury criteria is that we identified and excluded those patients who met the anatomic or physiologic components of the Field Triage Decision Scheme. This likely explains the difference in our findings with a recent study by Isenberg, Cone, and Vaca which found that intrusion was 58% sensitive and 92% specific.[17] Further, because we interviewed the EMS provider to specifically obtain the various criteria of the Decision Scheme, we were not subject to as many of the documentation errors and missed data found in retrospective studies. We believe studies must evaluate the mechanism of injury criteria as they are meant to be used by EMS providers; specifically, after identifying those critically ill patients who meet the anatomic or physiological criteria. This study did not evaluate if changing the order of the current steps of the Decision Scheme would improve the accuracy of the Scheme. Future research should be conducted to evaluate the order of the steps to maximize accuracy.

We used the 1999 Field Triage Decision Scheme in this study instead of 2006 Scheme because the 2006 Scheme excluded many of the mechanism of injury criteria. Specifically, deformity, extrication time, initial speed, and rollover were removed from the mechanism of injury criteria in the 2006 update. Our data support the removal of rollover since it was shown to be a poor predictor regardless of the number of turns the vehicle sustained. Although vehicles that rollover have been shown to be associated with a large proportion of motor vehicle deaths,[18] our contrasting finding is likely because those studies did not exclude patients who met the physiologic and/or anatomic criteria. That is, it is likely that rollover is not a significant predictor because most injured rollover victims are identified by the physiologic or anatomic criteria, and those who are not identified by the first two criteria, apparently do not need the resources of a trauma center. Our findings also support the removal of initial speed greater than 40 mph from the Field Triage Scheme. This is probably because estimated initial speed does not correlate with change in velocity at the time of the crash.[19] However, we did find that when the cut point was increased above 50 mph the positive likelihood ratio increased to make it a moderate predictor. It is possible that increasing the cut point may make this variable a better predictor. Perhaps surprisingly, our data shows that extrication time and deformity were good to moderate predictors of trauma center need. The importance of these variables should be re-evaluated and considered for inclusion in future revisions of the Field Triage Scheme.

It is also important to note that while this study evaluated patients seen at the trauma center, it did not limit its analysis to those patients identified by EMS as needing the trauma center. Previous studies only used a population of patients identified by EMS as severe trauma patients.[6] Those studies would have had a limited ability to evaluate under-triage (inappropriate transport to a non-trauma center), since patients who were not recognized as severe traumas were not included in the study. While our study was not population based we did have the full range of injury severity and thus were able to consider both under- and over-triage while at the same time ensuring that hospital based care and decisions were as close to standardized as possible since all patients were treated in a state designated level 1 trauma center.

We used death, ICU admission, or non-orthopedic surgery as our primary measure for trauma center need. We also conducted a secondary analysis using ISS as a secondary outcome measure. This change in outcome affected the mechanism of injury criteria that were identified as good or moderate predictors (Table 4), but did not for poor predictors. We made the composite measure our primary outcome because we were able to collect the patients' actual resource use at the trauma center and felt that ISS has been used as a proxy measure when that level of information was not available. However, for research in field triage decision making to progress, an accepted gold standard that establishes need for a trauma center is necessary. It is important to note that the NSCOT study which found improved survival among patients treated at a level 1 trauma center used an ISS greater than 15 to identify severe trauma patients.[4]

Analysis of the ROC curve data will assist those considering changes to the Field Triage Decision Scheme by allowing them to explore the effect of using different cut points. However, it is important to emphasize that the measurements analyzed were estimates made by EMS field providers while they were treating the patient and without any additional training in how to make those estimates. As such, we do not know if these estimates were accurate. For example, EMS providers were asked "How long do you estimate it took to extricate the patient from the vehicle?" Therefore, we evaluated the ability of real-world EMS estimations to identify trauma center need, but cannot determine if actual measures are predictive of trauma center need. Future research might consider whether measurement training would improve estimation accuracy and if so, would it improve triage accuracy. All of the communities that contributed data to this study used a locally modified version of the Field Triage Decision Scheme for their trauma protocols and expected their providers to determine the patient's mechanism of injury.

Limitations

This study was limited by its use of a convenience sample. We were able to gather basic data on the eligible patients who were not included in the study and found the two populations to be similar (Table 1). The benefit of this sampling scheme was that we were able to conduct direct provider interviews and thus have gathered complete information on the Field Triage Decision Scheme criteria. This would not have been possible with a medical record review and it was not possible to obtain the resources that would have been needed to interview EMS providers for all patients.

This was not a population based study. Patients with minor injuries could have been transported to our participating hospitals or to other hospitals within the study communities. This might have created some bias in our study. Further, while we were able to assess over-triage by examining the full range of patients who were brought to the study hospitals, our patient populations may not be representative of injured patients who were transported to other facilities. However, the three hospitals that participated in this study are large and treat a large percent of the injured patients in their communities and it seems unlikely that there was a systematic difference between the field presentation of patients transported to the study facilities compared to other facilities in the community.

The advantage of only studying patients seen at these facilities was that they all had access to the same resources and level of provider training. This means that it is likely our outcome was consistent across each site, but since long-term follow up after patient discharge was not conducted to confirm the patient's final status, we would not have identified patients who were misclassified due to a missed diagnosis.

Conclusion

The mechanism of injury criteria used in the 1999 version of the Field Triage Decision Scheme resulted in significant over-triage. Death of another occupant, fall distance, and extrication time were found to be good predictors of trauma center need when a patient does not meet the anatomic or physiologic criteria. Intrusion, ejection, and vehicle deformity were found to be moderate predictors. The remaining mechanism of injury criteria were found to be poor predictors; motor vehicle crash speed, rollover, pedestrian or bicyclist thrown or run over, pedestrian or bicyclist striking vehicle speed, motorcycle crash speed, and separation of rider from motorcycle.

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Table 1

Comparison of Patients Included in the study to those who did not have an interview conducted

	Included (n=11,892)	Missed (n=8,650)
Male	51%	52%
Mean age	48 years	47 years
Admitted	36%	33%
Died	2%	1%
Mechanism of Injury		
Assault	11%	18%
Fall	38%	40%
Motor Vehicle Crash	39%	35%
Motorcycle crash	5%	3%
Pedestrian/bicyclist struck	5%	3%
Other	2%	1%

Table 2

Comparison of those who met the Mechanism of Injury Criteria from the 1999 Field Triage Decision Scheme and Their Need for a Trauma Center

	Met any mechanism of injury criteria	None of the mechanism of injury criteria met
Needed the resources of a trauma center* **	204	310**
Did not need the resources of a trauma center	2,159*	6,810

Sensitivity = 39.7%; 95% Confidence Interval 35.6% – 44.0%

Specificity = 75.9%; 95% Confidence Interval 75.0% – 76.8%

Positive Likelihood Ratio = 1.65; 95% Confidence Interval 1.47 – 1.85

* Patients who would have been over triaged using the first 3 steps of the Field Triage Decision Scheme

** Patients who would have been under triaged using the first 3 steps of the Field Triage Decision Scheme

*** Trauma Center Need defined as death, admitted to ICU, or non-orthopedic surgery within 24 hours of arrival.

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Table 3

Sensitivity, Specificity, Positive Likelihood Ratio of Each Triage Criteria for Determining Trauma Center Need**

Mechanism of Injury	Triage Criteria	Number that met the Criteria	Sensitivity*	Specificity*	+LR*
Motor Vehicle Crash	Death of another occupant	25	3% (0.7% – 5.9%)	99.5% (99.3% –99.7%)	6.8 (2.7 – 16.7)
	Extrication >20min	105	11% (6.4% – 15.4%)	98% (97.4% – 98.3%)	5.0 (3.2 – 8.0)
	Intrusion >12″	202	16% (11.0% – 21.8%)	96% (95.0% – 96.3%)	3.7 (2.6 – 5.3)
	Ejection	38	3% (0.4% – 5.1%)	99% (98.9%– 99.4%)	3.2 (1.3 – 8.2)
	Deformity >20″	457	24% (17.9% – 30.2%)	89% (88.5% – 90.4%)	2.3 (1.7 – 3.0)
	Speed >40mph	969	42% (34.9% – 49.2%)	77% (75.9% – 78.6%)	1.8 (1.5 – 2.2)
	Rollover	523	13% (8.2% – 18.0%)	87% (86.2% – 88.3%)	1.0 (0.7 – 1.5)
Fall	Fall >20ft	36	4% (1.3% – 6.9%)	99% (98.9% – 99.5%)	5.2 (2.4 – 11.3)
Pedestrian/bicyclist struck by a car	thrown or run over	251	65% (48.6% – 80.8%)	46% (41.8% – 51.2%)	1.2 (0.9 – 1.6)
	Struck at speed >5mph	314	82% (69.5% – 95.2%)	33% (28.7% – 37.6%)	1.2 (1.0 – 1.5)
Motorcycle crash	Speed >20mph	297	77% (65.5% – 88.4%)	32% (27.3% – 36.7%)	1.1 (0.96 – 1.3)
	Rider separated from motorcycle	350	83% (72.4% – 93.0%)	19% (14.8% – 22.7%)	1.0 (0.9 – 1.2)

* 95% Confidence Interval shown in parenthesis.

** Trauma Center Need defined as death, admitted to ICU, or non-orthopedic surgery within 24 hours of arrival.

Table 4

Comparison of Positive Likelihood Ratio's by Outcome Definition

Mechanism of Injury	Criteria	Composite Outcome** +LR*	ISS>15 + LR*
Motor Vehicle Crash	Death of another occupant	6.8(2.7 – 16.7)	5.5 (2.2 – 13.6)
	Extrication > 20 min	5.0(3.2 – 8.0)	3.6 (2.2 – 5.9)
	Intrusion > 12″	3.7(2.6 – 5.3)	2.9 (2.0 – 4.2)
	Ejection	3.2(1.3 – 8.2)	7.1 (3.6 – 14.1)
	Deformity > 20″	2.3(1.7 – 3.0)	2.0 (1.6 – 2.7)
	Speed > 40 mph	1.8 (1.5 – 2.2)	1.7 (1.4 – 2.0)
	Rollover	1.0(0.7 – 1.5)	1.2 (0.9 – 1.7)
Fall	Fall >20ft	5.2(2.4 – 11.3)	2.1 (0.8 – 5.2)
Pedestrian/bicyclist	Thrown or run over	1.2(0.9 – 1.6)	1.3 (0.99 – 1.6)
	Struck at speed> 5 mph	1.2(1.0 – 1.5)	1.1 (0.95 – 1.4)
Motorcycle crash	Speed > 20 mph	1.1(0.96 – 1.3)	1.1 (0.9 – 1.3)
	Rider separated from motorcycle	1.0(0.9 – 1.2)	1.1 (1.0 – 1.2)

*95% Confidence Interval shown in parenthesis.

**Composite Outcome defined trauma center need as death, admitted to ICU, or non-orthopedic surgery within 24 hours of arrival.

Table 5

Result of the ROC Curve Analysis for Fall Height Identifying Trauma Center Need*

Cut Point	Sensitivity	Specificity	Correctly Classified	+LR
≥ 5 ft	32%	85%	82%	2.1
≥ 10 ft	21%	92%	88%	2.6
≥ 15 ft	11%	96%	92%	3.2
≥ 20 ft	7%	98%	93%	3.8
≥ 25 ft	3%	99%	94%	4.4
≥ 30 ft	3%	100%	95%	8.5
≥ 35 ft	**2%**	**100%**	**95%**	**12.3**
≥ 40 ft	1%	100%	95%	7.4
≥ 45 ft	1%	100%	95%	4.6

*Composite Outcome defined trauma center need as death, admitted to ICU, or non-orthopedic surgery within 24 hours of arrival.

Table 6

Result of the ROC Curve Analysis for Pedestrian or Bicyclist Struck Striking Vehicle Speed Identifying Trauma Center Need*

Cut Point	Sensitivity	Specificity	Correctly Classified	+LR
≥ 10mph	100%	4%	12%	1.0
≥ 20mph	86%	40%	44%	1.4
≥ 30mph	75%	66%	67%	2.2
≥ 40mph	39%	89%	85%	3.6
≥ 50mph	11%	99%	91%	10.2
≥ 55mph	**11%**	**100%**	**92%**	**30.6**

*Composite Outcome defined trauma center need as death, admitted to ICU, or non-orthopedic surgery within 24 hours of arrival.

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Table 7

Result of the ROC Curve Analysis for Estimated Motorcycle Speed Prior to the Crash Identifying Trauma Center Need*

Cut Point	Sensitivity	Specificity	Correctly Classified	+LR
≥ 5mph	98%	3%	14%	1.0
≥ 20mph	93%	22%	30%	1.2
≥ 30mph	85%	39%	44%	1.4
≥ 40mph	52%	72%	70%	1.9
≥ 50mph	26%	87%	80%	2.0
≥ 60mph	15%	94%	85%	2.4
≥ 80mph	**11%**	**99%**	**89%**	**19.6**

*Composite Outcome defined trauma center need as death, admitted to ICU, or non-orthopedic surgery within 24 hours of arrival.

Table 8

Result of the ROC Curve Analysis for Patient's Extrication Time Following a Motor Vehicle Crash Identifying Trauma Center Need*

Cut Point	Sensitivity	Specificity	Correctly Classified	+LR
≥ 5 min	44%	82%	80%	2.4
≥ 10 min	38%	88%	85%	3.1
≥ 20 min	17%	96%	93%	4.4
≥ 30 min	9%	98%	94%	5.3
≥ 40 min	4%	99%	95%	6.9
≥ 80 min	**1%**	**100%**	**96%**	**43.2**
≥ 90 min	1%	100%	96%	21.6

*Composite Outcome defined trauma center need as death, admitted to ICU, or non-orthopedic surgery within 24 hours of arrival.

Table 9

Result of the ROC Curve Analysis for Estimated Maximum Intrusion in the Patient's Vehicle Identifying Trauma Center Need*

Cut Point	Sensitivity	Specificity	Correctly Classified	+LR
≥ 2″	56%	79%	78%	2.7
≥ 12″	33%	90%	88%	3.4
≥ 24″	9%	98%	95%	4.7
≥ 36″	3%	100%	96%	7.0
≥ 66″	**1%**	**100%**	**96%**	**12.0**

*Composite Outcome defined trauma center need as death, admitted to ICU, or non-orthopedic surgery within 24 hours of arrival.

Table 10

Result of the ROC Curve Analysis for Estimated Maximum Deformity of the Patient's Vehicle Identifying Trauma Center Need*

Cut Point	Sensitivity	Specificity	Correctly Classified	+LR
≥ 10″	76%	54%	55%	1.7
≥ 20″	32%	87%	85%	2.4
≥ 30″	13%	95%	92%	2.7
≥ 40″	4%	98%	94%	2.3
≥ 50″	2%	99%	95%	3.3
≥ 66″	**2%**	**100%**	**96%**	**5.3**
≥ 72″	1%	100%	96%	4.2

*Composite Outcome defined trauma center need as death, admitted to ICU, or non-orthopedic surgery within 24 hours of arrival.

Table 11

Result of the ROC Curve Analysis for Estimated Speed of the Patient's Vehicle Prior to the Crash Identifying Trauma Center Need*

Cut Point	Sensitivity	Specificity	Correctly Classified	+LR
≥ 5mph	96%	14%	17%	1.1
≥ 20mph	85%	29%	31%	1.2
≥ 40mph	59%	66%	66%	1.7
≥ 50mph	36%	83%	81%	2.1
≥ 60mph	15%	93%	90%	2.1
≥ 70mph	6%	98%	94%	2.6
≥ 80mph	1%	100%	96%	2.3
≥ 90mph	1%	100%	96%	4.6
≥ 100mph	**1%**	**100%**	**96%**	**5.8**

*Composite Outcome defined trauma center need as death, admitted to ICU, or non-orthopedic surgery within 24 hours of arrival.

Table 12

Result of the ROC Curve Analysis for Estimated Number of Quarter Turns the Patient's Vehicle Turned Identifying Trauma Center Need* Criteria

Cut Point	Sensitivity	Specificity	Correctly Classified	+LR
≥ 1	100%	0%	4%	1.0
≥ 2	82%	21%	23%	1.0
≥ 4	59%	56%	56%	1.3
≥ 8	**29%**	**83%**	**81%**	**1.7**
≥ 16	6%	95%	92%	1.1

*Composite Outcome defined trauma center need as death, admitted to ICU, or non-orthopedic surgery within 24 hours of arrival.