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Does EMS Perceived Anatomic Injury Predict Trauma Center Need?

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Abstract

Objective—Our objective was to determine the predictive value of the anatomic step of the 2011 Field Triage Decision Scheme for identifying trauma center need.

Methods—EMS providers caring for injured adults transported to regional trauma centers in 3 midsized communities were interviewed over two years. Patients were included, regardless of injury severity, if they were at least 18 years old and were transported by EMS with a mechanism of injury that was an assault, motor vehicle or motorcycle crash, fall, or pedestrian or bicyclist struck. The interview was conducted upon ED arrival and collected physiologic condition and anatomic injury data. Patients who met the physiologic criteria were excluded. Trauma center need was defined as non-orthopedic surgery within 24 hours, intensive care unit admission, or death prior to hospital discharge. Data were analyzed by calculating descriptive statistics including positive likelihood ratios (+LR) with 95% confidence intervals.

Results—11,892 interviews were conducted. One was excluded because of missing outcome data and 1,274 were excluded because they met the physiologic step. EMS providers identified 1,167 cases that met the anatomic criteria, of which 307 (26%) needed the resources of a trauma center (38% sensitivity, 91% specificity, +LR 4.4; CI: 3.9 - 4.9). Criteria with a +LR ≥5 were flail chest (9.0; CI: 4.1 - 19.4), paralysis (6.8; CI: 4.2 - 11.2), two or more long bone fractures (6.3; CI: 4.5 - 8.9), and amputation (6.1; CI: 1.5 - 24.4). Criteria with a +LR >2 and <5 were penetrating injury (4.8; CI: 4.2 - 5.6), and skull fracture (4.8; CI: 3.0 - 7.7). Only pelvic fracture (1.9; CI: 1.3 - 2.9) had a +LR less than 2.

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Conclusions—The anatomic step of the Field Triage Guidelines as determined by EMS providers is a reasonable tool for determining trauma center need. Use of EMS perceived pelvic fracture as an indicator for trauma center need should be re-evaluated.

Keywords

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

Introduction

Injury is the fifth leading cause of death for all Americans.[1] Injury accounts for approximately one third of all emergency department visits[2] and 40% of all Emergency Medical Services (EMS) transports.[3] Prior to the 1970's, trauma patients were transported to the nearest hospital without regard for institutional capability, or resource utilization.[4] In 1976, the American College of Surgeons (ACS) identified the need for specialized hospitals dedicated to the care of the injured patients.[5] This gave prehospital care providers the important role of deciding when a trauma victim needs to be transported to a trauma center. In 1986, to assist prehospital care providers in making this decision, the ACS included a prehospital triage scheme in their publication, the “Optimal Resources for the Care of the Seriously Injured.” The triage scheme has been updated periodically, but it has always required the prehospital care provider to evaluate three distinct areas, (1) the patient's physiologic status, (2) the presence of specific anatomic injuries, and (3) sustaining a mechanism of injury that has a high likelihood of resulting in injury. Changes to these criteria have attempted to be evidence-based, however the literature in this area is limited.[6]

The process that prehospital care providers use to identify patients that require the resources of a trauma center is important. Under-triage, or the transport of patients with serious injuries to a non-trauma center, may result in increased morbidity and mortality.[7] Conversely, over-triage, or transporting a less seriously injured patient to a trauma center, can potentially strain the resources of a community's EMS and trauma systems. This strain can take the form of economic consequences for both the bypassed hospitals and for the patient and their families who must pay for transport. Further, over-triage may unnecessarily increase the risk of injury to the patient and EMS crew related to the potential hazards associated with traveling by helicopter or with lights and siren.[8-10]

A study using the National Trauma Data Bank demonstrated that when ICD-9-CM codes are used to assign the anatomic criteria, they have a sensitivity of 26% and a specificity of 86%.[11] As ICD-9-CM codes are determined after hospital evaluation, these findings may not accurately reflect the performance of the anatomic criteria for determining trauma center need when used by prehospital care providers who have limited access to diagnostic tools. One previous study used a questionnaire to study the anatomic injuries identified by EMS providers, and found that the anatomic criteria had a sensitivity of 45% and positive predictive value of 22%.[12] However, this study may not reflect how well the anatomic criteria will work in relation to the Field Triage Guidelines because the Guidelines are intended to be used in a stepwise fashion: patients who meet the first step (the physiologic criteria) should not be considered in evaluating the second step (the anatomic criteria).

The objective of this study was to determine the ability of prehospital care provider identified anatomic criteria to predict trauma center need in injured patients who did not meet the physiologic criteria. A secondary objective was to determine the accuracy of EMS assessments of anatomic injury compared to hospital coded ICD-9-CM discharge diagnoses.

Methods

This study is a secondary analysis of prospectively collected data from another study. [13] A prospective cohort study was conducted in the emergency departments of three regional trauma centers between March 2007 and March 2009. These hospitals were large tertiary care hospitals which were also state-designated level 1 regional trauma centers. They treated numerous injured patients transported by EMS who were not considered to have severe injures as well as those patients who had severe trauma. We identified a convenience sample of injured patients who were assaulted, in a motor vehicle or motorcycle crash, fell, or were struck by a vehicle while walking or riding a bicycle, and were transported to a participating emergency department by ambulance. The EMS provider in charge of each patient's care was interviewed to determine which of the 2011 Field Triage Decision Scheme criteria the patient met.

After each enrolled patient was discharged from the hospital or emergency department, the medical record was reviewed using a structured data collection instrument. This review determined the care the patient received in the hospital and their discharge diagnoses including their biller assigned ICD-9-CM nature of injury (N) and external cause of injury (E) codes. Data abstraction was done by the research coordinator at each site.

The EMS provider interview data were reviewed, and any case that met the physiologic step of the field triage criteria was excluded from further analysis. Of the remaining cases, any patient that met any of the anatomic criteria based on provider interview was considered positive for the anatomic step of the Field Triage Guidelines. The primary study outcome was trauma center need, which was defined as admission to the intensive care unit, death prior to discharge, or non-orthopedic surgery within 24 hours of hospital arrival.

The data was analyzed using descriptive statistics, including sensitivity, specificity, and positive likelihood ratios (+LR) with 95% confidence intervals. Accuracy of EMS identified anatomic injuries was determined using ICD-9-CM codes (Table 1). The sensitivity and specificity of the EMS estimates of injury were compared to the ICD-9-CM identified criteria.

Results

11,892 patients were enrolled in the study. Of those, 1,274 met the physiologic criteria of the field triage scheme and were not included in any additional analysis. One additional patient was excluded due to lack of follow up data, leaving 10,617 cases for the study analysis. Eight percent of included patients met at least one of the anatomic criteria but did not require the resources of a trauma center (i.e., over-triage) (Table 2). The overall sensitivity and specificity of EMS identified anatomic criteria was 38% (95% CI:35%-42%) and 91% (95% CI:91%-92%) respectively with a positive likelihood ratio of 4.4 (95% CI: 3.9-4.9).

Based on the ICD-9-CM billing codes 2,156 cases met the anatomic criteria, of which 434 (20%) needed the resources of a trauma center. The overall sensitivity and specificity of ICD-9-CM identified criteria was 54% (95% CI:51%-58%) and 83% (95% CI:82%-83%) respectively with a positive likelihood ratio of 3.1 (95% CI: 2.9-3.3). Table 3 shows the sensitivity, specificity and likelihood ratios for each of the anatomic criteria as identified by EMS providers and at hospital discharge. All injuries identified by EMS providers, with the exception of pelvic fractures, have positive likelihood ratios >2, indicating they are good predictors for identifying the need for a trauma center. When pelvic fractures were identified at the time of discharge from the hospital, the positive likelihood ratio increased to 6.2. Using billing codes instead of EMS findings, the positive likelihood ratio of each criteria was similar except paralysis became a poor predictor and skull and pelvic fractures became good predictors (amputation not analyzed, n=1). When comparing EMS findings to billing codes, the positive likelihood ratios ranged from 1.9 to 49.7 (Table 4).

Discussion

To be a useful tool for prehospital providers, the Field Triage Guidelines must be simple enough to be able to be used in the prehospital environment given the available resources, while still accurately identifying patients who need the resources of a trauma center. This study found that the Anatomic Step of the Field Triage Guidelines as identified by prehospital providers is a reasonable predictor of trauma center need. When ICD-9-CM codes are used to determine if the Anatomic Step was met, accuracy improved. This is not surprising given that the determination of ICD-9-CM codes is not done until the patient's hospital treatment is complete and it is possible to use advanced diagnostic equipment that cannot be used in the prehospital setting to make the determination. This suggests that if we could improve the identification of anatomic injuries in the prehospital setting, we may be able to improve field triage decision making. However, this may be difficult since the detection of many of these injuries may require diagnostic imaging or other advanced diagnostic tools or skills that cannot be brought into the prehospital setting.

While we found that the Anatomic Criteria were useful, it is important to note that many patients who needed the resources of a trauma center were not identified after applying the Physiologic and Anatomic steps of the 4 step Field triage Guidelines. There were 503 subjects who needed the resources of a trauma center, but were not identified by either of these criteria. Our previous analysis found that 204 of those patients would have been identified by the mechanism of injury step.[13] This suggests that additional criteria are needed to identify patients who need the resources of a trauma center beyond the currently used Anatomic, Physiologic, and Mechanism of Injury Steps of the Guidelines. This may mean that the criteria included in the fourth step should be used to select patients for the trauma center, rather than just increasing the index of suspicion, but it's more likely that research is needed to identify additional criteria that can be incorporated into the guidelines. It has been shown that the 2006 revisions to the Field Triage Guideline published in 1999, decreased over-triage while creating a small increase in under-triage. However, regardless of the version used the under-triage rates far exceed the ACS-COT 1-5% recommendation, with a 23 and 28% under-triage rate respectively.[14]

Like the anatomic step overall, each individual Anatomic criterion with the exception of EMS identified pelvic fracture was found to be a good predictor of trauma center need. Interestingly, pelvic fractures that were identified at the time of hospital discharge were a strong predictor of trauma center need. This finding may be due to the inherent difficulty in identifying pelvic fractures without diagnostic imaging that is not available in the prehospital setting. This criterion should be re-evaluated to determine if it should be removed from the Field Triage Guidelines or if there are other signs that can be identified in the prehospital setting that can be used to identify patients with potential pelvic fractures. This is particularly important given that the pelvis is an underappreciated source of major hemorrhage in trauma patients.

This study was limited by the difficulty encountered when attempting to match ICD-9-CM codes to the Anatomic Criteria. We had to make several adjustments which likely jeopardized the evaluation; particularly in regard to the accuracy of EMS findings for those criteria where we had to use a broad ICD-9-CM definition (Table 1). For example, we had to use the ICD-9-CM code for a single long bone fracture since there is no code for two or more long bone fractures. Further, while we recorded all of the assigned ICD-9-CM codes for each case, we do not have any information on the accuracy of the code assignments by the billing teams. It is therefore possible that some codes were missed or recoded inaccurately. An additional limitation of this study, unrelated to coding, is the fact that information specific to mangled or degloved extremities was not included in the EMS interview. This resulted in the exclusion of this criterion from analysis of the overall sensitivity and specificity of the Anatomic Step of the Field Triage Guidelines. It is unknown how this would have affected our results, since there is also no corresponding ICD-9-CM code for this type of injury. Further, this study was conducted prior to the release of the 2011 guidelines so we asked if patients had a “flailed chest”, rather than using the current language which is “chest wall instability or deformity (e.g., flailed chest)”. Therefore, it is unknown whether that change will improved the identification of patients who need a trauma center.

Conclusion

In patients who do not meet physiologic criteria, the anatomic step of the Field Triage Guidelines is useful for predicting trauma center need. This is true even when EMS identified injuries did not match discharge diagnoses. While most of the individual Anatomic Criterion were good predictors of trauma center need, pelvic fracture may be difficult to determine in the prehospital setting due to limited diagnostic resources and warrants additional evaluation in order to enhance its accuracy.

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Table 1

ICD-9-CM N or E-Codes used to indicate a specific anatomic Injury and Their Limitations

Anatomic Component Conditions	ICD-9-CM N/E-codes	Limitations
Amputation proximal to the wrist and ankle	887 (arm or hand amputation), 897(leg amputation)	Can not verify that these are proximal to wrist or ankle – but there are separate codes for fingers which were not used (885 thumb and 886other fingers)
Flail Chest	807.4	
Open or depressed skull fracture	Open: 800.5-800.9, 801.5-801.9, 803.5-803.9, 804.5-804.9 Closed:800-800.4, 801-801.4, 803-803.4	Used all major open and closed head injuries (may or may not be depressed)
Paralysis	951-957	Used any injury to the spinal nerves (may or may not have paralysis)
Pelvic Fracture	808	
Penetrating injuries to the head, neck, torso, and extremities proximal to elbow and knee	E955 (suicide by gun), E956(suicide by cutting), E965 (gun intentional), E922 (gun accidental), E966 (stabbing or piercing) E920 (Accidents caused by cutting and piercing instruments or objects), E970 (Injury due to legal intervention by firearms), E974 (Injury due to legal intervention by cutting and piercing instrument), E985 (Injury by firearms air guns and explosives) E986 (Injury by cutting and piercing instruments undetermined whether accidentally or purposely inflicted)	No specific diagnostic codes for penetrating injuries. ICD-9-CM E-codes used in place of ICD-9-CM nature of injury (N) codes
Two or more proximal long-bone fractures	812 (any humerus fracture), 819 (two arm fractures and ribs or sternum), 820 (any femur fracture), 821(any femur fracture)	There is no way to identify two fractures so used any one

Table 2

Overall Evaluation of the Anatomic Criteria

	Met any anatomic criteria	None of the anatomic criteria met
Needed the resources of a trauma center	307	497**
Did not need the resources of a trauma center	860*	8,953

*Patients who would have been over triaged

**Patients who would have been under triaged

Table 3

Evaluation of Anatomic Criteria by Individual Injury

Anatomic criteria identified by EMS Assessment	Number that met criteria	Sensitivity (95% CI)	Specificity (95% CI)	Likelihood Ratio (95% CI)	Number met Anatomic Criteria identified by ICD-9-CM Diagnosis	ICD-9-CM identified likelihood ratio
Amputation proximal to wrist and ankle	9	0.4% (0.1-1.1)	99.9 (99.9-100.0)	6.1 (1.5-24.4)	1	Cannot calculate
Flail Chest	26	1.4% (0.7-2.4)	99.8% (99.7-99.9)	9.0 (4.1-19.4)	10	28.5 (7.4-110.0)
Open or depressed skull fracture	82	2.9% (1.8-4.3)	99.4% (99.2-99.5)	4.8 (3.0-7.7)	167	13.6 (10.1-18.3)
Paralysis	67	3.0 (1.9-4.4)	99.6 (99.4-99.7)	6.8 (4.2-11.2)	440	0.7 (0.5-1.1)
Pelvic fractures	205	3.5% (2.3-5.0)	98.2% (97.9-98.5)	1.9 (1.3-2.9)	272	6.2 (4.9-7.9)
Penetrating injury to the head, neck, torso, and extremities	699	24.6% (21.7-27.8)	94.9% (94.4-95.3)	4.8 (4.2-5.6)	695	4.8 (4.1-5.5)
Two or more proximal long bone fractures	135	5.7 (4.2-7.6)	99.1% (98.9-99.3)	6.3 (4.5-8.9)	718	2.0 (1.7-2.5)

95% Confidence Intervals shown in parentheses

Table 4

EMS Provider Assessment of Anatomic Criteria compared to ICD-9-CM Diagnosis identified criteria

Criterion	EMS Identified	Number present per ICD-9-CM	Number absent per ICD-9-CM	Sensitivity	Specificity	+LR
Amputation proximal to wrist and ankle	Yes	0	9	0 (0-97.5)	99.9 (99.8-100)	Cannot calculate
	No	1	10,607			
Flail chest	Yes	1	25	10.0 (0. 3-44.5)	99.8 (99.7-99.8)	42.4 (6.3-284.0)
	No	9	10,582			
Open or depressed skull fracture	Yes	19	63	11.4 (7.0-17.2)	99.4 (99.2-99.5)	18.9 (11.6-30.8)
	No	148	10,388			
Paralysis	Yes	5	62	1.1 (0.4-2.6)	99.4 (99.2-99.5)	1.9 (0.8-4.6)
	No	435	10,115			
Pelvic fracture	Yes	50	155	18.4 (14.0-23.5)	98.5 (98.2-98.7)	12.3 (9.1-16.5)
	No	222	10,190			
Penetrating injury to the head, neck, torso, and extremities	Yes	543	156	78.1 (74.9-81.1)	98.4 (98.2-98.7)	49.7 (42.3-58.3)
	No	152	9,766			
Two or more proximal long bone fractures	Yes	46	89	6.4 (4.7-8.5)	99.1 (98.9-99.3)	7.1 (5.0-10.1)
	No	672	9,810			

95% Confidence Intervals shown in parentheses