The American Journal of Surgery 216 (2018) 813–818

Contents lists available at ScienceDirect

The American Journal of Surgery

journal homepage: www.americanjournalofsurgery.com

Undertriage after severe injury among United States trauma centers and the impact on mortality☆

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ARTICLE INFO

Article history:
Received 14 February 2018
Received in revised form
9 May 2018
Accepted 17 July 2018

Keywords:
Triage
Undertriage
Trauma
Trauma system

ABSTRACT

Introduction: Severely injured patients should receive definitive care at high acuity trauma centers. The purposes of this study were to determine the undertriage (UT) rate within a national sample of trauma centers and to identify characteristics of UT patients.
Methods: Severely injured adults ≥16 years were identified from the 2010-2012 NTDB. UT was defined as those who received definitive care or died at hospitals without state or ACS level I or II verification. Risk factors for UTT and the impact of UT on mortality were determined.
Results: Of 348,394 severely injured patients, 11,578 (3.3%) were UT. Older, less severely injured, and certain minority patients were most likely to be UT. After risk adjustment, predictors of UT included increased age and minority race. Increased injury severity and comorbidity were protective (all $p < .05$). Mortality was greater in UT patients regardless of ISS (OR = 1.32, $p < .001$).
Conclusion: The low UT rate in this study demonstrates the effectiveness of triage practices amongst ACS and state verified centers however age, race, and insurance disparities in UT should be improved.

Purpose

Severely injured patients have improved outcomes at trauma centers capable of providing definitive care.[1,2] To identify patients who may benefit from this specialized trauma care, the American College of Surgeons Committee on Trauma (ACS COT) developed the Field Triage Decision Scheme in 1986 and updated it in conjunction with the Centers for Disease Control in 2011.[3] These guidelines are intended to maintain undertriage (UT) rates below 5%. For those patients without immediate access to high acuity centers, the inclusive trauma system model allows them to receive initial treatment at lower acuity facilities then promptly transferred to level I or II centers. By participating in larger trauma systems, these lower acuity centers can help to efficiently provide optimal care and triage of their patient population.

Existing studies describe UT rates in excess of 5%; however, often do not reflect the ability of both Level I and II centers to provide definitive care and for lower acuity centers within a trauma system to treat these patients prior to transfer. Furthermore, these studies do not differentiate between UT rates amongst patients treated within trauma systems comprised of ACS- and state-verified centers of varied acuity versus those at all hospitals regardless of trauma system participation. While demographic disparities in UT besides age have not been well studied, UT has been identified as a particular concern in older patients and Medicare beneficiaries. More than half of severely injured patients 55 years of age or greater are not initially cared for at level I or II centers.[4,5]

The purpose of this study was to determine the percentage of undertriaged patients in a large national sample of injured patients treated at ACS- and state-verified trauma centers, hypothesizing that the UT rate amongst patients treated at non-level I or II trauma centers would be lower than UT rates previously reported for patients treated at all hospitals in the United States. Secondary aims included determination of patient characteristics associated with UT and evaluation of the impact of UT on survival.

☆ This work originated from Mayo Clinic, Rochester, MN.

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https://doi.org/10.1016/j.amjsurg.2018.07.061
0002-9610/

Methods

Cohort and data source

Severely injured adults age 16 years or greater were identified from the 2010-2012 National Trauma Data Bank (NTDB) for inclusion. Severe injury was defined as an injury severity score (ISS) of 16 or greater in line with ACS COT guidelines based on greater mortality in this population.[6] Patients with any abbreviated injury severity (AIS) score of 6 were excluded as were those with no state or ACS trauma center verification level available.

The NTDB research data set (RDS) contains patient-level data provided by trauma centers to the ACS COT that is released on an annual basis.[7] All participating institutions have ACS COT or state level verification and participation is mandatory for ACS level I, II, and III centers.[8] It is the largest national trauma data source; greater than two thirds of hospitals in 35 states contributed data in 2011 for a total of 773,299 patient entries from 744 institutions in the United States and Puerto Rico.[9] Participating institutions utilize standard inclusion criteria and variable definitions according the NTDB data dictionary and all contributed data is reviewed by the NTDB Validator prior to inclusion. AIS data were obtained from the NTDB RDS, which utilizes ICD-9-CM codes to calculate AIS in a standardized fashion using the ICDMAP-90 crosswalk.

Information collected for each patient entry included age, sex, ISS, race, primary payer, regional AIS scores, trauma type (blunt, penetrating, other), admission vital signs and Glasgow coma scale (GCS), comorbidities present on admission, in-hospital complications, hospital characteristics including verification level, length of stay, disposition and mortality. The NTDB uses standardized definitions of comorbidities and complications which can be found in the data dictionary. Hospital characteristics included ACS COT verification level, state verification level, profit status, and teaching status. UT was defined as receiving definitive care at NTDB hospitals without state or ACS level I or II verification. Appropriately triaged patients were those treated at level I or II centers or those treated initially at lower acuity centers (defined as level III, IV, other, or no verification) and transferred out. For the purpose of this study, the assumption was made these transfers were made to higher acuity level I or II centers. Invasive procedures required after arrival were compared between UT and appropriately triaged patients using the Healthcare Cost and Utilization Project major diagnostic and therapeutic procedure ICD-9 code classifications.[10]

Univariate analyses comparing continuous variables were performed using student's *t* tests or Wilcoxon rank sum tests and categorical variables were compared using chi squared and analysis of variance tests. Continuous results are presented as mean (standard deviation, sd) or median (interquartile range, IQR). Categorical variables are presented as percentages. Clinically and statistically significant variables were then used to construct a multivariable stepwise logistic regression model with the outcome of UT to see if patient or injury characteristics independently associated with UT could be identified. To evaluate the impact of UT on mortality, univariate analysis was done comparing patients who survived to discharge versus those who did not. A second multivariable logistic regression model accounting for patient clustering by hospital with the outcome of in-hospital mortality was created. Statistically and clinically significant variables from the univariate analysis were included to see if UT independently impacted risk of in-hospital mortality. The mortality regression model accounted for patient clustering by facility. Statistical analysis was performed using SAS (version 9.4, Cary, North Carolina). A p value of $< .05$ was acknowledged as significant.

Results

Overall cohort

There were 355,510 severely injured patients identified for potential inclusion in this study. After excluding those with missing ACS and state verification level ($n = 7116$) the final cohort was 348,394. Mean age was 49.0 (21.7) years and 30.0% were female. The median ISS was 21 with the majority of patients suffering blunt trauma (77.6%). Unadjusted in-hospital mortality was 15.4%.

UT rates

UT occurred in 11,578 patients (3.3%). Of the 336,816 appropriately triaged patients, 330,080 (98.0%) were treated at a state or ACS level I or II center and the remaining 6736 (2.0%) were brought initially to lower acuity centers and transferred. Of UT patients, 3300 (52.1%) received definitive care at a center with ACS level III verification and 10,653 (68.7%) at a center with state level III verification. The UT rate increased over time from 3.1% in 2010 to 3.4% in 2011 and 3.5% in 2012 ($p < .001$). By region, UT was most frequent in the South (4.4%) and West (4.4%) versus 2.4% in the Midwest and 1.2% in the Northeast ($p < .001$).

Characteristics of UT patients

The unadjusted risk of UT was greater in female patients (3.6 vs 3.2%, $p < .001$) and those with advanced age; patients $\geq$65 years of age were most likely to be UT (Table 1). Similarly, those with Medicare insurance were most likely to be UT (4.3%) compared to those with private insurance (3.2%), no insurance (3.3%), and Medicaid (2.5%; $p < .001$). UT also varied by race, occurring in 23.7% of Native Hawaiian or Pacific Islander patients, 3.4% of whites, and 2.2% of blacks ($p < .001$). Patients with preexisting comorbidities were less likely to be UT than those without (3.1 vs 3.7%, $p < .001$). Injury severity was lower in UT than appropriately triaged patients and those with penetrating injuries were less likely to be UT than bluntly injured patients (2.4 vs 3.4%, $p < .001$). There was no difference in severity of head injury (median AIS 4 vs 4, $p = .26$). A procedure was required in 36.5% of UT patients versus 47.8% of appropriately triaged patients ($p < .001$).

Adjusted predictors of UT

Several factors remained associated with UT after adjustment using multivariable logistic regression (Table 2). Age $\geq$65 years remained most predictive of UT (OR = 1.4, $p < .001$) as did Medicare insurance (OR = 1.22, $p < .001$). Native Hawaiian or Pacific Islander race was also highly predictive of UT (OR = 9.76, $p < .001$). Penetrating injury mechanism and the presence of comorbidities remained protective. The odds of UT decreased with increasing injury severity.

Outcomes in UT vs appropriately triaged patients

Median length of stay was shorter in UT vs appropriately triaged patients (5 vs 6 days, $p < .001$) and in-hospital complications were less frequent (33.9 vs 47.9%, $p < .001$). The most common complication in both groups was pneumonia (4.8 vs 7.9%, $p < .001$). Overall mortality was greater in UT than appropriately triaged patients (16.9 vs 15.4%, $p < .001$) and this persisted when mortality was stratified by ISS (Fig. 1). The lowest mortality was seen in appropriately triaged patients initially treated at level III centers (8.7% vs 19.7% UT, $p < .001$). Complications and injuries in UT patients who died are shown in Table 3; intracranial hemorrhage and lung injury