The magic number: Are improved outcomes observed at trauma centers with undertriage rates below 5%?

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BACKGROUND: The American College of Surgeons Committee on Trauma (ACSCOT) advises trauma centers maintain <5% undertriage rate (UTR), but provides limited rationale for this figure. We sought to determine whether patients managed at Level I/II trauma centers with a UTR less than 5% had improved outcomes compared with centers with greater than 5% UTR. We hypothesized that similar overall adjusted outcomes would be observed at trauma centers in Pennsylvania regardless of their compliance with ACSCOT undertriage recommendation.

METHODS: The Pennsylvania Trauma Outcome Study database was retrospectively queried for all trauma patients managed at accredited adult Level I/II trauma centers (n = 27) from 2003 to 2015. Patients with missing data on Injury Severity Score and/or Trauma Activation Status were excluded from the analysis. Institutional UTR were calculated for all trauma centers based on ACSCOT criteria (Injury Severity Score >15; no trauma activation) and were categorized into less than 5% or greater than 5% subgroups. A multilevel mixed-effects logistic regression model assessed the adjusted impact of management at centers with less than 5% undertriage. Statistical significance was set at p less than 0.05.

RESULTS: A total of 404,315 patients from 27 trauma centers met inclusion criteria. Institutional UTRs ranged from 0% to 20.5%, with 15 centers exhibiting UTR less than 5% and 12 centers with UTR greater than 5%. No clinically meaningful difference in unadjusted mortality rate was observed between subgroups (<5% UTR: 5.19%; >5% UTR: 5.20%; $p < 0.001$). In adjusted analysis, no difference in mortality was found for patients managed at centers with less than 5% UTR compared to those with greater than 5% UTR (adjusted odds ratio, 1.06; 95% confidence interval, 0.85–1.33; $p = 0.608$).

CONCLUSION: Achieving ACSCOT less than 5% undertriage standards appears to have limited impact on institutional mortality. Further research should seek to identify new triage criteria that can be uniformly applied to all trauma centers. (*J Trauma Acute Care Surg.* 2018;85: 752–755.

LEVEL OF EVIDENCE: Epidemiological study, level III.

KEY WORDS: Undertriage; overtriage; trauma center; triage.

The mission of the American College of Surgeons Committee on Trauma (ACSCOT) is to enhance the management of injured patients at every level of care, as well as to create and implement uniform standards for the care of injured patients.[1] The ACSCOT advises trauma centers to maintain less than 5% undertriage, but does not explicitly provide the rationale as to why the goal of undertriage was set specifically to less than 5%.[2] The issue of undertriage has been prioritized because of the potential preventable mortality and morbidity associated with delays in definitive care provided to trauma patients.[2] Undertriage is a source of concern given the positive impact of appropriate level of treatment on outcome of trauma patients. The National Study on Costs and Outcomes of Trauma study demonstrated a 25% reduction in mortality when patients were treated appropriately at accredited trauma centers versus those treated at nontrauma centers.[3] This positive impact on patient outcomes was made more evident as severity of injury increased.[3]

Studies on undertriage are not infrequent in the trauma literature with several attempts made to determine existing rates of undertriage. Staudenmayer et al.[4] reported ~35% of undertriage of trauma patients in the state of California over a five year period. Xiang et al.[5] reported an annual national emergency department UTR of 34%. While calculating UTRs is inherently fraught with difficulty, the issue is further complicated by lack of a universal definition of undertriage. It can be defined in a myriad of ways – one definition of undertriage is inappropriate triage of severely injured (Injury Severity Score [ISS] >15) patients to non-Level I/II trauma centers. The ACSCOT provides an alternate criterion utilizing injury severity and trauma activation status, which was employed in this study (detailed in the Methods section) to calculate UTR.

The aim of this study was to investigate the impact of trauma center adherence to the recommended less than 5% UTR by ACSCOT, specifically whether patients receiving definitive care at trauma centers that maintained UTR less than 5% had improved outcomes compared to those treated at trauma centers with greater than 5% UTR. We hypothesized that similar overall adjusted mortality would be observed at trauma centers in Pennsylvania regardless of their compliance with ACSCOT undertriage recommendation of less than 5% UTR.

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METHODS

A retrospective analysis of the Pennsylvania Trauma Outcome Study (PTOS) database, the statewide trauma registry of the Pennsylvania Trauma Systems Foundation, was conducted for all trauma patients managed at accredited Level I/II adult Pennsylvania trauma centers (n = 27) from 2003 to 2015. It should be noted that accreditation of trauma centers within Pennsylvania include annual minimum volume requirements defined as number of PTOS qualified patients treated with Level I TCs requiring 600 PTOS qualified patients and Level II TCs requiring 350 PTOS qualified patients per year. Exclusive pediatric trauma centers were not included in this study. Inclusion into the PTOS data set is highly stringent and dependent on meeting at least one of the following criteria: death secondary to trauma, intensive care unit/step-down unit admissions, length of stay (LoS) longer than 48 hours or LoS between 36 hours and 48 hours with ISS of 9 and admitted transfers in/out of the hospital. A vast array of deidentified patient information is available in this data set, including patient demographics, injury time/mechanism, preexisting conditions, prehospital data, ED data, admission status, operative management, outcome measures, incidence of complications, and ISS values among other fields.

Institutional UTRs were calculated per guidelines by ACSCOT—patients with major trauma (defined as ISS >15) who were not activated were compared with the total number of patients (including major and minor trauma) who were not activated. Institutions were categorized into less than 5% or greater than 5% undertriage subgroups. Patients missing ISS and/or Trauma Activation status data were excluded from analysis. The primary outcome was in-patient mortality. In addition, institutional overtriage rate (OTR) was calculated by comparing patients with ISS less than 15 activated as trauma alerts with all trauma activations. Univariate analysis using Kruskal-Wallis, two-sample t- and Fischer's exact tests was performed on continuous and categorical variables to determine baseline demographic differences between patients managed at trauma centers with less than 5% UTR and greater than 5% UTR. Undertriage rates were additionally stratified into categories (<5%, 5–9.9%, 10–14.9%, 15–19.9%, 20–24.9%) to assess differences in mortality rates.

A multilevel mixed-effects logistic regression model controlling for several covariates (age, injury severity, systolic blood pressure, and Glasgow Coma Scale [GCS] score on admission and injury year) assessed the adjusted impact of management at centers with less than 5% undertriage on mortality. Age and injury severity variables were stratified within the model with the youngest age group (<50) and least severe injury scores (ISS, 0–9) serving as reference intervals. Age, injury severity, systolic blood pressure, and GCS score were included in the model because of their well-established association with trauma mortality.[6–9] The area under the receiver operating characteristic (AUROC) was calculated for the mortality model to determine its discriminant capacity. Statistical significance was set at p less than 0.05, and all analyses were performed using Stata/MP, version 15.0 (Stata Corp, College Station, TX). This study was reviewed and approved by the Lancaster General/Penn Medicine Institutional Review Board.

RESULTS

From the 27 adult Level I/II trauma centers that submitted injury data to the PTOS data set during the study interval, a total of 404,315 patients met inclusion criteria. Institutional UTRs ranged from ~0% to ~20.5% across the study period, with 15 centers exhibiting UTR of <5% and 12 centers with >5%.

A breakdown of study population demographics is presented in Table 1. Univariate analysis demonstrated a statistically significant difference in mortality between the sub-groups (<5% UTR: 5.19%; >5% UTR: 5.20%; $p < 0.001$) that has questionable clinical relevance given the miniscule difference in absolute mortality rates. Statistical differences in GCS and mean hospital LoS between the two groups were not clinically meaningful (Table 1). Figure 1 displays the variance in mortality rate within each UTR category without evidence of a clear pattern with respect to institutional mortality rate and increasing UTR category.

Calculated institutional overtriage rates varied over a range from 52.2% to 78.1%. Figure 2 examines the relationship between undertriage and overtriage rates and demonstrates a correlation between increasing UTR and lower overtriage rates (R^2 = 30.9%). Controlling for age, injury severity, systolic blood

TABLE 1. Study Population Demographics

Variables	Study Population (N = 404,315)	UTR <5% (n = 195,507)	UTR >5% (n = 208,808)	*p*
Age: mean ± SD, y	50.16 ± 24.9	51.07 ± 25.6	49.30 ± 24.3	<0.001
Median (IQR)	50.0 (28.0–72.0)	51.0 (28.0–74.0)	49.0 (28.0–70.0)	
Sex (male), n (%)	248,803 (61.6)	117,774 (60.2)	131,029 (62.8)	<0.001
ISS, n (%)				
0–9	219,105 (54.2)	110,637 (56.6)	108,468 (51.9)	
10–16	88,691 (21.9)	42,616 (21.8)	46,075 (22.1)	
17–25	59,685 (14.8)	26,531 (13.6)	33,154 (15.9)	—
≥26	36,834 (9.1)	15,723 (8.0)	21,111 (10.1)	
GCS, mean ± SD	13.76 ± 3.3	13.82 ± 3.1	13.71 ± 3.3	<0.001
Hospital LoS: mean ± SD, d	5.72 ± 8.0	5.51 ± 8.1	5.92 ± 7.9	<0.001
Mortality, n (%)	21,007 (5.20)	10,139 (5.19)	10,868 (5.20)	<0.001

SD, standard deviation; IQR, interquartile range.

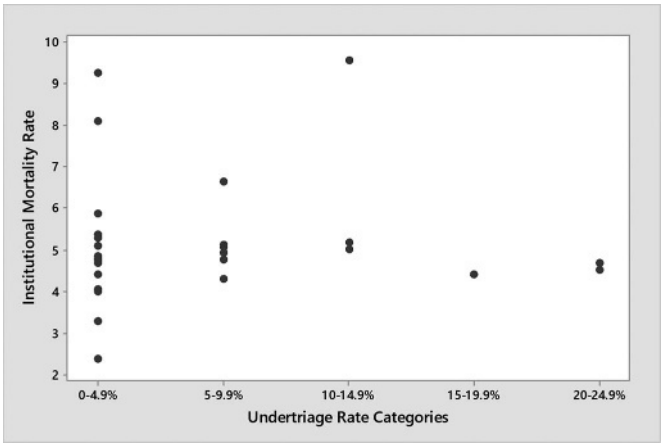

Figure 1. Mortality rate across UTR categories.

pressure, and GCS upon admission and injury year, adjusted analysis did not reveal any significant differences in mortality (Table 2) for patients managed at centers with less than 5% UTR compared with those with greater than 5% UTR (adjusted odds ratio, 1.06; 95% confidence interval, 0.85–1.33; p = 0.608). The AUROC for the mortality model was 0.93, signifying good model discrimination of survivors from fatalities.

TABLE 2. Adjusted Odds Ratios for Mortality for Centers With UTR <5% Versus >5%

N = 367,468	Mortality	
Variables	**Adjusted Odds Ratio** (95% CI)	***p***
UTR <5%	**1.06** (0.85–1.33)	**0.608**
Age, y		
<50	Reference	—
50–59	1.89 (1.76–2.04)	<0.001
60–69	4.18 (3.89–4.50)	<0.001
70–79	9.36 (8.74–10.01)	<0.001
80 and above	17.75 (16.71–18.84)	<0.001
ISS		
Mild (0–9)	Reference	—
Moderate (10–16)	2.08 (1.95–2.22)	<0.001
Severe (17–25)	4.68 (4.41–4.96)	<0.001
Profound (26–75)	11.13 (10.49–11.81)	<0.001
Systolic blood pressure	0.98 (0.98–0.98)	<0.001
GCS	0.75 (0.74–0.75)	<0.001
Injury year	1.00 (1.00–1.01)	0.003
AUROC	0.93	

DISCUSSION

While the association of higher UTRs and poor patient outcomes at nontrauma centers has previously been established in the literature, this study was unique in attempting to ascertain the nature of the relationship between UTR and mortality at established trauma centers. The results of this study demonstrate that adoption of the less than 5% UTR recommended by ACSCOT does not improve trauma mortality and there is insufficient evidence to validate the notion that the less than 5% "acceptable" UTR at Level I/II trauma centers is the critical threshold level above which patient mortality is significantly worse. It should be noted that although this study did not find a difference in less than 5% versus greater than 5% UTR and mortality, it does not invalidate previous studies that may have noted a difference with respect to undertriage and mortality. Many existing studies in the literature define undertriage as major trauma treated at nontrauma centers or lower-level trauma centers (level III/IV), which is vastly different from the definition employed in this study. To directly compare with the results of this study, it is crucial that the same criterion of undertriage is used. Although the 5% UTR does not appear to serve as a cutoff value with respect to in-patient mortality at trauma centers, it may still have relevance to other patient outcomes not examined in this study, such as extended emergency department LoS, incidence of complications, functional status at discharge, and so on.

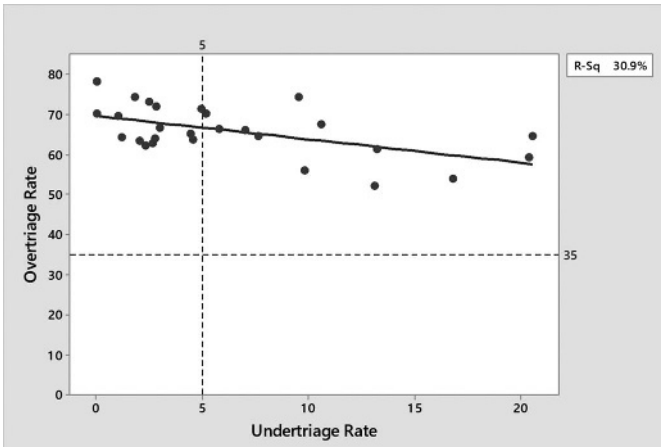

Figure 2. Scatterplot of the relationship between undertriage and overtriage rates.

Notwithstanding the lack of definitive evidence behind the UTR recommended by ACSCOT, strict adherence to less than 5% UTR may not be a practical goal for many trauma centers. Mohan et al. conducted an analysis on the feasibility of adopting less than 5% institutional UTR and determined that a fivefold increase in transfers to trauma centers was necessary to meet ACSCOT recommendations.[10] This theoretical strategy could help institutions achieve the target UTR but is not necessarily a pragmatic proposition given the tremendous burden of increased transfers on the limited resources of trauma centers.[10]

Increased transfers to trauma centers would ideally selectively result in greater volume of severely injured patients but, in reality, also comprise of patients with minor injuries. This leads to an unfortunate rise in secondary overtriage. One study conducted at a rural level I trauma center reported a secondary overtriage rate of 26% and acknowledged that surgical interventions were frequently unnecessary in this cohort, who would likely have had similar outcomes with treatment at lower level trauma center or nontrauma center facilities.[11] While overtriage to trauma centers does not generally have an adverse effect on patient outcomes, other drawbacks exist that incentivize minimization of overtriage rate. Newgard et al.[12] determined that level I trauma centers had the highest costs per patient when

adjusted across the injury spectrum. Reduction in overtriage is generally expected to lead to reduction in acute injury costs and is highly desirable.[12]

To achieve a UTR less than 5%, ACSCOT deems an overtriage rate of 25% to 35% acceptable.[2] All of the adult trauma centers included in this study exceeded the acceptable range of overtriage rates with the smallest rate calculated to be 52.2%. The results of this study demonstrated that trauma centers with UTRs at the higher end of the spectrum were associated with lower overtriage rates. While attainment of less than 5% UTR across all trauma centers may currently be a highly idealistic goal, perhaps striking a balance between undertriage and overtriage rates is a better approach in predicting patient outcomes. Further research with greater number of trauma centers is needed to determine whether an optimal ratio of undertriage to overtriage rates exists.

This study was not without its limitations. The retrospective nature of the injury data, as well as reliance on a database, was potential sources of bias in this analysis. While the PTOS database is an excellent source of patient demographic and outcome data, it does not include facility specific characteristics. Consideration of interfacility differences in patient volume was attempted with inclusion of only TCs with minimum annual volume of 350 PTOS patients. However, large differences in patient volume at the largest Level I TCs versus the smallest Level II TCs could have impacted the findings of this study. Another facility characteristic that could not be considered in this analysis was the setting (rural vs. urban), which could have affected the type and extent of injury of presenting patients. Additionally, other factors, such as proximity to other hospitals, teaching status of institutions along with regional variations in emergency medical services education and protocols regarding trauma activation could have impacted the findings of this study. This analysis could also be strengthened by examining the variability of institutional UTRs over the study period to discern whether fluctuations in adherence to less than 5% UTR can impact patient outcomes. It also needs to be acknowledged that, given the relatively few number of trauma centers included in this analysis (n = 27), it was not possible to definitively identify a cut-off value for UTR with respect to improving mortality outcomes.

CONCLUSION

The importance of appropriate triage of critically injured patients to appropriate level of care has been emphasized countlessly, but no conclusive identification of an acceptable minimal UTR has materialized. Achieving ACSCOT less than 5% undertriage standards appears to have limited impact on overall institutional trauma patient mortality. Perhaps, incorporation of other criteria with UTR can better predict institutional trauma mortality. Further research should seek to identify new triage criteria based on empirical evidence that can be uniformly applied to all trauma centers.

AUTHORSHIP

S.J. participated in the study design, data interpretation, and article preparation, E.H.B. participated in the study design, data interpretation, and editorial oversight. B.W.G. participated in the study design, data analysis, article preparation. A.D.C. participated in the study design and data interpretation. M.J.R. participated in the study design and data interpretation. F.B.R. participated in the study design, data interpretation, editorial oversight.

DISCLOSURE

The authors declare no funding or conflicts of interest.

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