

## THE INCREASING NATIONAL BURDEN OF POTENTIALLY PREVENTABLE DEATHS DUE TO HEMORRHAGE

Zain G. Hashmi, MD; Russell L. Griffin, PhD;  
Stacy Drake, PhD, MPH, RN; McKinley Williams, BS; Sheza Hassan, MD;  
Junaid Razzak, MD; John B. Holcomb, MD  
University of Alabama at Birmingham

**Introduction:** The use of low titer group O whole blood (LTOWB) in bleeding trauma patients is increasingly common. However, some centers do not administer RhD-positive LTOWB to females <50 due to concerns about RhD-negative patients becoming D-alloimmunized. This study examined practices related to LTOWB transfusion as they pertain to age and sex using a large prospectively collected database.

**Methods:** This was a secondary analysis of the Shock, Whole blood, and Assessment of TBI (SWAT) trial: a prospective, multicenter observational cohort study where outcomes following transfusion to 1046 injured patients were analyzed at 7 level 1 trauma centers between 2018-2021. The proportion of patients who received LTOWB or exclusively conventional components (CT) was examined over the course of the original study and stratified by age and sex. We characterized the RhD-types of females <50 and surveyed the RhD-blood product selection practices for trauma patients at these centers.

**Results:** A total of 1046 patients were evaluated; 130 females <50, 77 females ≥50; 661 males <50, and 178 males ≥50. Of females <50 13/128 (10.2%) were RhD-negative. Of females <50, 34/130 (26.2%) received LTOWB including 4/33 (12.1%) who were RhD-negative. In contrast, 587/916 (64%) of all other recipients received LTOWB. RhD blood product selection practices varied considerably between institutions, e.g., only 1/7 centers stocks RhD-negative LTOWB, and 1/7 centers does not transfuse RhD-positive LTOWB to adult females <50. Multiple strategies for deciding which patients should receive RhD-positive or negative LTOWB and CT in initial resuscitation as well as the use of D-alloimmunization prophylaxis for RhD-negative females <50 after receipt of RhD-positive blood were reported. Over the study period, the percentages of females <50 who received LTOWB between 2018-2021 were 0%, 28.3%, 35.1% and 25.0%.

**Conclusion:** There were fewer than the expected 15% of RhD-negative females <50 in this cohort of patients. Most institutions transfused LTOWB to females <50 but these patients were less likely to receive LTOWB than other recipients. As the understanding of safety of RhD-positive products in females <50 improves, the reasons why a lower proportion of females <50 compared to other patient groups received LTOWB need to be elucidated.

# THE UTILITY OF ADDING DELTA SHOCK INDEX TO STANDARD TRAUMA TRIAGE CRITERIA: A NTDB ANALYSIS

James Bardes, MD; Tanner Smida, MS;  
Bradley Price PhD; Alison Wilson, MD  
West Virginia University

**Introduction:** Shock index (SI) and delta shock index ( $\Delta$ SI) have shown utility identifying severe injury. Despite this, trauma team activation criteria (TTAC) do not include either. Using the National Trauma Data Bank, we aim to evaluate the effect of integrating  $\Delta$ SI and SI in standard TTAC.

**Methods:** Retrospective cohort study using the NTDB database 2017-2020. Patients with missing vital sign data were excluded. Subjects in the dataset were queried for standard TTAC and positive need for trauma intervention (NFTI) defined as appropriately classified. SI was calculated as heart rate divided by systolic blood pressure.  $\Delta$ SI was calculated as the change from prehospital SI to arrival SI. The accuracy for NFTI was determined from SI and  $\Delta$ SI in conjunction with standard TTAC. To optimize this approach a classification tree using a recursive partitioning algorithm was utilized to identify optimal cutoffs for SI and  $\Delta$ SI in TTAC.

**Results:** Over 911,000 patients were available for analysis. Using standard TTAC 69.5% were classified correctly, with the addition of SI or  $\Delta$ SI we found no improvement in classification accuracy. Utilizing the classification tree (Figure 1) and focusing on patients without mechanistic or anatomic TTAC (n >759,000), the NFTI accuracy is 71.7%. This approximates to approximately 23,000 additional trauma team activations with over 13,000 correctly triaged.

**Conclusion:** The use of both SI and  $\Delta$ SI in conjunction should be considered for addition to TTAC. Individually neither value adds significant value as a TTAC. While the NTDB does have limitations in the number of vital sign values available, this study demonstrates that combining measurements of SI and  $\Delta$ SI can achieve improvements in trauma triage. These findings call for additional study with more granular EMS datasets.

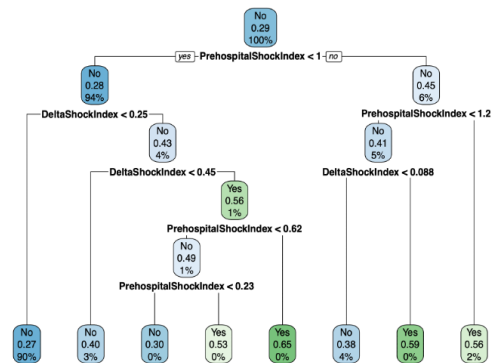


Figure 1. Classification tree  
Nodes on left side of rule are in agreement

## TOURNIQUET APPLICATION BY BYSTANDERS: MORE WORK TO DO

Robert Painter, MD; Andreina Giron, MD;  
John Schomberg, PhD, MPH; Yigit Guner, MD;  
Peter Yu, MD, MPH; Jeffry Nahmias, MD, MHPE; Sigrid Burruss, MD;  
Thomas K. Duncan, DO; Kenji Inaba, MD; Laura F. Goodman, MD  
Children's Hospital of Orange County

**Introduction:** Civilian prehospital tourniquet placement (TP) has increased over time. Studies have shown that prehospital TP may be associated with decreased hemorrhagic shock and improved survival, however tourniquets may be placed incorrectly or without clear indication. Additionally, no national study has evaluated outcomes of bystander TP. This study sought to compare outcomes of prehospital TP by emergency medical services providers (EMS) or first responders (police, fire) versus civilian bystanders, hypothesizing civilian TP would have less acuity improvement than EMS TP.

**Methods:** The 2017-2020 National Emergency Medical Systems Information Systems (NEMSIS) database was queried for TP for patients of all ages. Acuity was reported in the database, and improvement was defined as change from critical to emergent or lower acuity. Descriptive statistics for demographics, TP and improvement were completed. A multivariable analysis was also performed to determine associated improvement in acuity.

**Results:** 3,003 patients had prehospital TP, 85% of which were applied by EMS. There was a lower success rate of TP by bystanders (90% vs 97%,  $p<0.001$ ) compared to EMS and first responders. When combining all groups, there was a higher rate of improved acuity for TP after EMS arrival on site compared to before (65% vs 58%,  $p=0.002$ ). Placement of tourniquet by bystander was not associated with improvement in acuity (OR 1.1 95% CI 0.97-1.25,  $p=0.12$ ). However, TP by first responders was associated with improved acuity (OR 1.22 95% CI 1.01-1.44,  $p=0.02$ ).

**Conclusion:** Tourniquets are life-saving tools. First responders seemed to be trained adequately and EMS are critical for tourniquet success. While bystander TP appears to be less efficacious, bystanders are successfully using tourniquets. Trauma programs should consider outreach programs in their communities with respect to tourniquet application to save lives.

## AN ALARMING TURNING POINT IN BALTIMORE HOMICIDE TRENDS: ANALYSIS OF 6500 VIOLENT DEATHS

Samuel Okum, BA; James Byrne, MD, PhD;  
Ambar Mehta, MD, MPH; Nicole Lunardi, MD; Elliott Haut, MD, PhD;  
David Efron, MD; Joseph Sakran, MD, MPH, MPA  
Johns Hopkins Hospitals

**Introduction:** Freddie Gray's death in Baltimore police custody on April 19th, 2015 was followed by civil unrest and a sustained, citywide surge in interpersonal violence. Anecdotally, clinicians also observed a heightened pace with which patients presented with multiple—and more often lethal—injuries. This study thus quantified the temporal association between Gray's death and indicators of Baltimore homicide incidence and violence intensity.

**Methods:** Autopsy data was obtained for all homicides committed from 2005-2017 in Maryland. Decedents were grouped by mechanism of injury: gunshot wound (GSW), stab wound (SW), or other. The number of distinct GSW or SW sustained was collected for each victim of penetrating trauma. The primary outcome was the overall homicide rate. The secondary outcome was the 90th percentile of total wounds sustained by GSW and SW victims, which we defined as the high violence intensity threshold (HVIT).

Difference-in-differences regressions analyzed trends in homicide rates and HVIT by fiscal quarter; comparisons were made between trends from before and after the death of Freddie Gray. We separately evaluated trends in Baltimore and the rest of MD, the latter serving as an ecological control.

**Results:** Autopsy reports for 6508 homicides were evaluated (Baltimore City, 42%; rest of MD, 58%). Statewide, most deaths were due to gun violence (74%). Homicides from GSW were more common in Baltimore (79% vs. 70%), while homicides due to SW were more common in the rest of MD (16% vs. 11%). Following Gray's death, firearm-related homicides composed an increased proportion of city totals (77% of pre-event vs. 86% of post-event Baltimore homicides). This event was also associated with an increase in Baltimore homicide incidence by 13.1 per 100,000 persons (95% CI: 8.9-19.6;  $p < 0.001$ ). Accounting for trends in the rest of MD, the HVIT for GSW homicides increased from 8 to 10 after the event ( $p = .02$ ). There was no temporal change in the HVIT for SW homicides ( $p = .47$ ).

**Conclusions:** After the death of Freddy Gray, the homicide rate grew significantly in Baltimore relative to the rest of MD. This was accompanied by a significant rise in violence intensity observed among firearm homicide victims in Baltimore. These findings coincided with increased prevalence of firearm-related injuries in Baltimore's homicide victim pool, suggesting that a surge in firearm violence may have precipitated the trends observed.

## **BEDSIDE BRILLIANCE: USE OF BMAT SCORE TO REDUCE ACUTE PHYSICAL AND OCCUPATIONAL THERAPY REFERRALS IN TRAUMA PATIENTS**

Audrey L. Spencer, MD; Hunter Alexander, BS;  
Muhammad Haris Khurshid, MD; Adam Nelson, MD, FACS;  
Omar Hejazi, MD; Collin Stewart, MD, FACS;  
Stanley Okosun, MD, MS, FACS; Michael Ditillo, DO, FACS;  
Louis J. Magnotti, MD, MS, FACS; Bellal Joseph, MD, FACS  
The University of Arizona

**Introduction:** Banner Mobility Assessment Tool (BMAT) for nurses is a tool to identify the mobility status of patients admitted to hospitals. However, there is limited data on the role of BMAT in identifying the trauma patients who might benefit most from physical or occupational therapy (PT/OT) services. This study aims to assess the association between BMAT scores and the true need for PT/OT and outcomes in trauma patients.

**Methods:** We performed a retrospective review of adult ( $\geq 18$  years) trauma patients who were admitted to our level I trauma center and were consulted for PT/OT services in 2021. We excluded patients who died during the admission. Patients were stratified based on BMAT score: 1 (maximal assistance), 2-3 (moderate assistance), and 4 (minimal assistance). The primary outcome was the rates of acceptance and deferral of acute skilled PT/OT by therapists. The secondary outcome was discharge disposition. Multivariable logistic regression analyses were performed to identify the independent association between BMAT scores and outcomes.

**Results:** We identified a total of 320 patients who met the inclusion criteria (BMAT 1: 70, BMAT 2-3: 225, BMAT 4: 25). The mean age was 55 years and 53% were male. The median ISS was 8. Patients in the lower BMAT score categories received higher rates of acute skilled PT/OT services (BMAT 1: 100% vs BMAT 2-3: 89% vs BMAT 4: 20%,  $p < 0.001$ ) and were more likely to be discharged to rehabilitation or skilled nursing facilities (BMAT 1: 79% vs BMAT 2-3: 53% vs BMAT 4: 0%,  $p < 0.001$ ). On regression analyses, increasing BMAT scores were independently associated with reduced odds of receiving acute PT/OT services (aOR = 0.19, 95%CI = 0.12 – 0.33,  $p < 0.001$ ) and discharge to rehabilitation or skilled nursing facilities (aOR = 0.25, 95%CI = 0.15 – 0.43,  $p < 0.001$ ). All BMAT 4 patients who received acute PT/OT services (20%) were advised home discharge with outpatient PT/OT follow-up and the rest (80%) were deferred as they were independent with activities of daily life with no acute skilled OT/PT services required.

**Conclusion:** BMAT accurately predicts the need for acute PT/OT consultation. With increased burden and limited availability of PT/OT services, BMAT can be used to avoid potentially unnecessary PT/OT referrals to reduce healthcare resource utilization.

# CELL PHONE MEASURED POPULATION MOBILITY AND INTERACTIONS AS A PREDICTOR OF TRAUMA VOLUME AND TRAUMA CENTER NEED

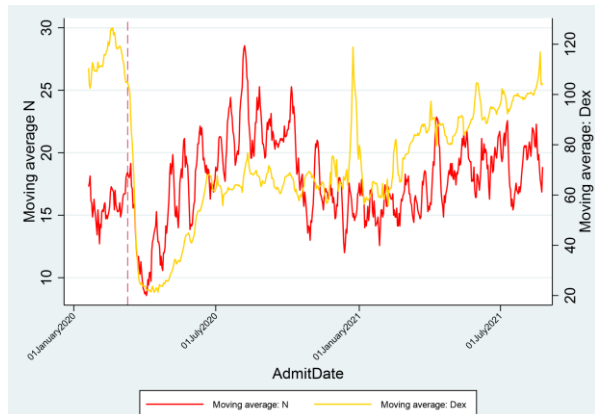
Pawan Mathew, MD; Jane Keating, MD; Manuel Moutinho, MD;  
Robert Becher, MD; Adrian Manung, MD; Kimberly A. Davis, MD, MBA;  
Elena Graetz, PhD; Eric Schneider, PhD; Kevin M. Schuster, MD, MPH  
Yale School of Medicine

**Introduction:** Predicting the need for trauma centers is based primarily on population. Population activity measured through cell phone tracking used for commercial marketing purposes may improve the prediction accuracy. Changing activity during the COVID-19 pandemic created a natural

**Methods:** Trauma admissions (TA) from all level I trauma centers in one state, January 2020 to August 2021, were aggregated and compared to the Device Exposure Index (DEX) which provides a standardized measure of cellular device interactions per day in a given county. Both were smoothed with a 7-day moving average. Correlation coefficients were calculated, and linear regression adjusted for autocorrelation and seasonality.

**Results:** The DEX and TAs declined sharply after pandemic lockdowns were implemented, with DEX and TAs following similar patterns across the participating centers (Figure). TAs and the DEX were correlated, Spearman's rho=0.2 ( $p < 0.05$ ). In regression, DEX was associated with TAs ( $p=0.034$ ). Half of low admission days ( $TA < 15$ ) occurred when the DEX was less than 50, whereas only a quarter of all high admission days ( $TA \geq 20$ ) occurred when the DEX was less than 50.

**Conclusion:** Shifting TA patterns at the onset of the COVID-19 pandemic, correlated with DEX suggesting this may be a valuable measure for long-term trauma center planning. Daily DEX may also help predict short-term TAs.



## FIVE YEAR, POST-IMPLEMENTATION ANALYSIS OF AN AIR EMS AUTO-LAUNCH SYSTEM FOR SEVERLY INJURED TRAUMA PATIENTS

Brennan Gagen, MD; Kunal Verma, BS;  
Justin Regner, MD; Chad Hall, MD  
Scott & White Memorial Medical Center

**Introduction:** Prolonged transport times and double transfers have the potential to worsen trauma mortality by delaying time to definitive hemorrhage control. The Air EMS Auto-Launch System (AALS) was developed to expedite care of severely injured trauma patients by prompting air EMS agencies to the scene of injury. This is the five-year analysis post-implementation of the AALS.

**Methods:** This study is a retrospective analysis at a Level 1 trauma center following the implantation of the AALS in 2018. Adult trauma patients from January 2015- September 2023 with ISS >15 were included. Transport origin, transport time, initial vital signs, and blood product administration data were collected. Mortalities on arrival, within 4, and 24 hours were compared before and after implementation. Preliminary analysis was completed with standard student t-test and Chi-Square test.

**Results:** A total of 695 patients met the inclusion criteria for the study. Following initiation of the system, there were significantly more patients that came directly from the scene compared to a referring hospital,  $\chi^2 (2, N=693) = 8.7, p < 0.05$ . The ISS scores of presenting patients were similar compared between before and after the implantation of the system, ( $27.90 \pm 11.95$  vs  $28.42 \pm 11.30, p = 0.603$ ). Patients dead on arrival and 4-hour mortality remained similar through 2023. Mortality at 24-hours was significantly lower in 2023, the fifth year after AALS implementation,  $\chi^2 (2, N=249) = 5.046, p < 0.05$ .

**Conclusion:** The AALS system decreased trauma transfers, promoting the opportunity to expedite hemorrhage control and improve mortality within 5 years of implementation. These results highlight the importance of rapid, definitive management and justify the ongoing use of the AALS system for severely injured trauma patients.

## **GREAT DISPARITIES EXIST IN PREHOSPITAL TRANSFUSION RESOURCES**

Justin Regner, MD; Chad Hall, MD  
Baylor Scott and White

**Introduction:** Hemorrhage remains the most common preventable cause of mortality in critically injured patients. While early transfusion improves survival in military & civilian settings, few institutions have implemented Low Titer O-Whole Blood (LTOWB) into their prehospital transfusion algorithms. We planned a survey to determine the variation in prehospital transfusion resources for trauma centers in the Southwestern US.

**Method:** Multicenter trials committee conducted an anonymous 26-question survey of prehospital blood transfusion resources. The survey included: trauma center demographics and location, number of Helicopter Emergency Medical Service (HEMS) and Ground EMS agencies, and types of blood products available. A single survey was filled out per center in coordination with the center's trauma medical director or trauma program manager. Descriptive statistics were utilized to determine variance.

**Results:** 36 trauma centers across 14 US states responded to the survey. The majority were level 1 trauma centers (30/36) in urban settings (20/36). Four trauma centers were rural. All centers received critical hemorrhaging trauma patients from both HEMS and EMS. 22 centers received critical patients from  $\geq 3$  HEMS agencies, and 13 centers have  $\geq 10$  EMS agencies transporting critical patients. EMS was the predominate mode of transportation for critically injured patients. Prehospital blood availability was more likely on HEMS (25/35) than EMS (9/35) as was LTOWB (18/35 vs 5/35). HEMS (16/35) was more likely to have plasma than EMS (1/35). 10 centers did not have any prehospital blood available by HEMS or EMS. Most critical, the four rural trauma centers had only 2 of 4 HEMS carry LTOWB and no EMS vehicles carried any blood products.

**Conclusion:** Our survey demonstrates significant discrepancies in prehospital blood availability and concerns that Ground EMS agencies are under-resourced for life sustaining therapies. While the majority of HEMS carried blood, ground EMS was the primary mode of transport for hemorrhaging trauma patients at most centers. Most significant, rural trauma centers, with the longest transport times, had the least access to prehospital blood. Further work is needed to better understand limitations in prehospital blood supply and how to make it available for all trauma centers.



## HAS NOTHING CHANGED? EVALUATING A DECADE OF EMERGENCY RESUSCITATIVE THORACOTOMY

Emanuele Lagazzi, MD; Vahe S. Panossian, MD;  
Wardah Rafaqat, MD; Ikemsinachi C. Nzenwa, MBChB, MS;  
Matthew Simpson; May Abiad, MD; Jonathan Parks, MD;  
Haytham M.A. Kaafarani, MD, MPH; George C. Velmahos, MD, PhD;  
John Hwabejire, MD, MPH; Michael DeWane, MD  
Massachusetts General Hospital

**Introduction:** The 2015 EAST guidelines have attempted to establish clear indications for Emergency Resuscitative Thoracotomy (ERT) to optimize procedural outcomes. The impact of the updated guidelines on current clinical practice and patient survival remains unknown. In this nationwide analysis, we aim to analyze changes in ERT utilization and survival patterns in trauma patients over the last decade.

**Methods:** The ACS-TQIP 2010-2020 was used to identify all patients  $\geq 15$  years old who underwent ERT within the first hour of hospital admission. ERT was defined using ICD-9 and ICD-10-PCS codes and ERT rates were calculated for every 100,000 trauma patients. Joinpoint Regression analysis was employed to identify any changes in procedure and survival rates. Patients were stratified based on the mechanism of injury - blunt vs. penetrating- and trauma center verification level to assess whether the performance of the ERT and survival rate trends varied through the years.

**Results:** 4,899 patients underwent ERT, with 3,464 (71%) for penetrating trauma. The average survival rate was 21.07% for penetrating trauma and 8.85% for blunt trauma. ERT was performed in level I trauma centers in 55% of cases, in level II in 14%, and in level III centers in 31% of cases. Following Joinpoint regression analysis, we noticed a significant decrease in ERT performance from 2010 to 2017, and an increase in ERT following 2017 in all trauma centers, even when stratifying the institutions based on ACS verification level. Following 2017, there has been a significant increase in ERT performance for penetrating trauma. ERT following blunt trauma has decreased from 2010 to 2020, albeit not significantly. However, no significant differences in survival were seen following the implementation of the 2015 guidelines regardless of the mechanism of injury or trauma center level.

**Conclusion:** Since 2017 there has been a nationwide increase in ERT performance for penetrating trauma compared to blunt trauma. However, despite nationally published guidelines intended to improve patient selection and outcomes, survival following ERT has not changed significantly in the past decade regardless of the mechanism of injury or trauma center level. These findings warrant further studies aimed at identifying if barriers exist to nationwide adherence to current clinical guidelines.

## **NOVEL STRATEGIES FOR RCTS FOR TRAUMA CARE: HARNESSING THE POWER OF CNTR, TQIP AND THE STEPPED WEDGE DESIGN**

Melanie Fritz, MD; Eileen M. Bulger, MD, FACS; Rosemary Kozar, MD;  
Avery B. Nathens, MD; Bret M. Hanlon, PhD; Lily Stalter, MS;  
Bhavin Patel, MPH; Michelle A. Price, PhD; Margaret L. Schwarze, MD  
University of Wisconsin

**Introduction:** Clinical research in the trauma population faces enrollment challenges associated with high acuity settings and difficulty obtaining surrogate consent. Passive data collection through the American College of Surgeons (ACS) Trauma Quality Improvement Program (TQIP) provides an opportunity to test the effect of minimal-risk, team-based interventions in a large cohort of seriously injured patients. The objective of this project was to design a randomized clinical trial (RCT) at high volume trauma centers, leveraging TQIP and the Coalition for National Trauma Research (CNTR), that could feasibly produce strong enrollment of trauma patients with judicious use of resources and provide a study design model that others might adopt for future research.

**Methods:** With support from CNTR and TQIP, we surveyed level 1 trauma centers to determine the number of eligible patients at US centers that were willing to participate. We calculated study size using estimates of eligible family and clinicians for survey completion and the TQIP variable for ICU length of stay (LOS). We identified covariates and other outcomes of interest in the ACS National Trauma Data Standard (NTDS) Data Dictionary and worked with TQIP to collect two additional patient outcomes (vital status at six months and quality assurance for ICU LOS).

**Results:** We designed an RCT with an estimated enrollment of 4,500 patients at eight trauma centers, funded by the NIH and approved by the IRB. The intervention, Best Case/Worst Case-ICU, is a team-based communication tool. We use a stepped wedge design to allow time for implementation at each study site and reduce confounding for temporal trends. For this study, consent is not required for intervention or patient data extraction, as the intervention and TQIP qualify as quality improvement efforts. TQIP developed an incremental data collection platform to capture additional patient outcome variables.

**Conclusion:** Leveraging CNTR and TQIP offers an ideal approach for overcoming the difficult barriers of enrolling trauma patients in clinical trials. This study design can be emulated for interventions implemented at the site level to generate important knowledge to advance the care of trauma patients.