

**COMPARISON OF 10 GAUGE VS 14 GAUGE ANGIOCATHETER FOR TREATMENT OF TENSION PNEUMOTHORAX AND TENSION INDUCED PULSELESS ELECTRICAL ACTIVITY WITH CONCOMITANT HEMORRHAGIC SHOCK: BIGGER IS STILL BETTER.**

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**Introduction:** Little is known regarding the effect of hemorrhagic shock on the diagnosis and treatment of tension pneumothorax (tPTX). Recently, the Tactical Combat Casualty Care (TCCC) guidelines included the 10-gauge angiocatheter (10g AC) as an acceptable alternative to the 14-gauge angiocatheter (14g AC). This study sought to compare these two devices for decompression of tPTX and rescue from tension-induced pulseless electric activity (tPEA) in the setting of a concomitant 30% estimated blood volume (EBV) hemorrhage.

**Methods:** Following a controlled hemorrhage, carbon dioxide was insufflated into the chest to induce either tPTX or tPEA. tPTX was defined as a reduction in cardiac output by 50%, and tPEA was defined as a loss of arterial waveform with mean arterial pressure (MAP) less than 20mmHg. The affected hemi-thorax was decompressed using a randomized 14g AC or 10g AC while a persistent air leak was maintained after decompression. Successful rescue from tPTX was defined as 80% recovery of baseline systolic blood pressure. Successful return of spontaneous circulation following tPEA was defined as a MAP>20mmHg. Primary outcome was success of device.

**Results:** Eighty tPTX and fifty tPEA events were conducted in thirty-eight adult Yorkshire swine. There were no significant differences in the baseline characteristics between animals or devices. In the tPTX model, the 10g AC successfully rescued 90% of events while 14g AC rescued 80% of events ( $p=0.350$ ). In the PEA model, the 10g AC rescued 87% of events while the 14g AC rescued only 48% of events ( $p=0.006$ ).

**Conclusion:** The 10g AC was vastly superior to the 14g AC for return of spontaneous circulation following tPEA in the setting of 30% hemorrhage. These findings further support the importance of larger caliber devices that facilitate rapid recovery from tPTX, particularly in the setting of polytrauma.

## CHARACTERIZATION AND INFLUENCE OF SCAPULA FRACTURES AMONG PATIENTS WHO UNDERGO SURGICAL STABILIZATION OF RIB FRACTURES

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**Introduction:** Current algorithms involving surgical stabilization of rib fractures (SSRF) do not consider specific fracture locations. The combination of displaced, sub-scapular rib fractures and a scapula fracture creates challenges for both rib exposure and fixation, which may in turn adversely affect both hardware longevity and shoulder function. We hypothesized that a scapula fracture is associated with both acute and long term morbidity among a sample of patients with sub-scapular rib fractures who underwent SSRF.

**Methods:** Retrospective review of prospectively-maintained SSRF databases from two high volume (at least 30 SSRF cases per year), level I trauma centers. The sample was comprised of patients with at least one bi-cortical, sub-scapular rib fracture, defined as ribs 2-7 within 2 cm of the edge of the scapula on admission CT chest. Patients were then grouped by the presence of a scapula fracture. Demographics, injury severity, scapula fracture morphology, acute outcomes, and the need for subsequent hardware removal were abstracted.

**Results:** 111 patients with a median of 4 (range 1-11) sub scapular fractures underwent SSRF and were analyzed. 68 (60.3%) patients had at least one sub-scapular plate placed. 31 (27.9%) patients had a scapula fracture; 2 were bilateral, 2 involved the glenoid (the remainder involved only the scapula body), and 1 underwent fixation (4 days following SSRF). There were no differences identified in patient demographics, injury severity, or rib fracture severity as a function of a scapula fracture (Table). The overall incidence of both acute re-operation (n=2, 1.8%) and long-term hardware removal (n=4, 3.6%) following SSRF was low. However, patients with a scapula fracture were significantly more likely to require hardware removal as compared to patients without a scapula fracture (9.7% vs. 1.3%, respectively, p=0.03). Furthermore, each case of hardware removal from a patient with a scapula fracture entailed removal of sub-scapular plates specifically due to a painful grinding sensation with shoulder movement. The singular case of hardware removal in a patient without a scapula fracture was due to infection of antero-lateral plates.

**Conclusion:** Ipsilateral scapula fractures were present in approximately one third of patients with displaced, sub-scapular rib fractures who underwent SSRF. The vast majority of scapula fractures involved the body (directly posterior to the rib fractures) and were not repaired. Patients with a scapular fracture were significantly more likely to require rib hardware removal, specifically in the sub scapular location. Alternative techniques to SSRF in this clinical scenario, including fixation to the inner rib cortex and simultaneous scapular body fracture repair, should be studied.

**A PROSPECTIVE STUDY TO ASSESS CYTOKINES (IL-1B, IL-6, IL-8, IL-10 & TNF-A) AND BIOMARKERS (vWF & CC-16) IN PATIENTS WITH CHEST TRAUMA AND THEIR CORRELATION WITH THORACIC TRAUMA SEVERITY SCORE AND PATIENTS' OUTCOME**

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**Introduction** - Thoracic trauma causes substantial morbidity and mortality. Severity of chest injury is assessed by Thoracic Trauma Severity Score (TTSS) but its association with cytokines and biomarkers and patient prognosis is not well elucidated. The aim of the study was to assay cytokines (IL-1 $\beta$ , IL-6, IL-8, IL-10& TNF- $\alpha$ ) and biomarkers (vWF, CC16) in patients of thoracic trauma and correlate it with TTSS and patients' outcome.

**Materials and Methods** - The study was conducted in the Division of Trauma Surgery & Critical Care of a level I Trauma Centre. In this prospective observational study, all patients of thoracic trauma who met the inclusion criteria and gave consent were included. Serum and Broncho-alveolar lavage (BAL) fluid samples from these patients were collected on four occasions. Thoracic trauma severity score was calculated in all patients. Patient outcome parameters included discharge or death, hospital stay and intensive care unit (ICU) stay. Healthy healthcare workers were selected as controls for serum samples. Patients of carcinoma esophagus with no evidence of tracheal involvement were selected as controls for BAL sample.

**Results** - Forty-three patients were included in the study. In trauma patients, IL-1 and IL-10 were increased both in serum and BAL fluid and IL-6 and IL-8 were increased in only BAL fluid. Clara Cell protein (CC16) was significantly reduced in BAL fluid. The mean TTSS of patients who died was significantly more than that of patients who recovered (7.9 days vs 6.2 days; p - 0.048). Patients with a high score also had a significant prolongation of ICU stay (17 days vs 10.2 days; p - 0.048). No significant difference was observed in these cytokines and biomarkers between patients who recovered and who died. However, it was seen that lower values of CC16 in BAL was associated with a prolonged hospital stay (Correlation Coefficient - 0.45; p - 0.005).

**Conclusions** - TTSS is an excellent modality to assess the insult incurred by a patient of chest trauma. Patients with a high TTSS (> 5) have significantly prolonged ICU stay. The mortality rate increases significantly with TTSS > 7. Protective role of CC-16 was observed in patients who recovered. Longer prospective studies are required to determine the role of cytokines and biomarkers in patients with thoracic trauma in predicting the patient's outcome.

**INTERLEUKIN-18: A ROBUST PREDICTOR OF ACUTE RESPIRATORY DISTRESS SYNDROME IN SEVERE BLUNT TRAUMA**

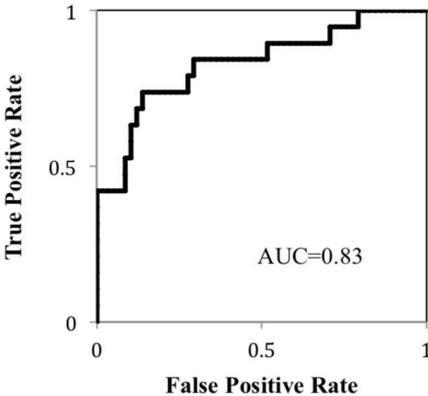
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**Introduction:** Direct pulmonary injury and innate immune response activation primes the lungs for acute respiratory distress syndrome (ARDS) in trauma. Recently identified as a key mediator in ARDS pathogenesis is the inflammasome dependent release of Interleukin-18 (IL-18). As such, we hypothesized plasma IL-18 is a diagnostic predictor of ARDS in severe blunt trauma.

**Methods:** Secondary analysis of the Inflammation and the Host Response to Injury database was performed on plasma cytokines collected within 12 hours of severe blunt trauma. Trauma related cytokines, including IL-18, were compared between ARDS and non-ARDS patients, and were evaluated for association to ARDS using logistic regression. Threshold cytokine concentrations predictive of ARDS were then determined using receiver-operating curve (ROC) analysis.

**Results:** Cytokine analysis of ARDS (n=19) compared to non-ARDS patients (n=61) demonstrated elevated plasma IL-18 in ARDS and IL-18 strongly correlated with ARDS on logistic regression after confounder adjustment (p=0.008). Additionally, ROC analysis revealed IL-18 as a strong ARDS predictor (AUC=0.83, figure 1), with a threshold IL-18 value of 170 pg/ml (Youden Index: 0.3). IL-18 remained elevated in ARDS compared to non-ARDS patients during the acute injury phase (p<0.02). Other trauma related cytokines did not correlate with ARDS.

**Figure 1: Initial IL-18 Level and ARDS Development**



**Conclusion:** In severe blunt trauma, IL-18 is a robust predictor of ARDS and remains elevated throughout the acute injury phase. These data support IL-18 as a key ARDS biomarker, promoting early identification of trauma patients at greater risk of developing ARDS. Timely recognition of ARDS and implementation of advantageous supportive care practices may reduce trauma related ARDS morbidity and costs.

## **TIMING OF REPAIR OF BLUNT TRAUMATIC THORACIC AORTIC INJURY: RESULTS FROM THE NATIONAL TRAUMA DATABANK**

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### **Introduction:**

Thoracic endovascular aortic repair (TEVAR) is currently considered the preferred operative treatment for blunt traumatic thoracic aortic injuries (BTAI), and its use is typically associated with improved outcomes compared to open surgical repair and nonoperative management. However, the optimal time from injury to repair is unknown and remains a subject of debate across societal clinical practice guidelines. The purpose of this study was to evaluate national trends in the management of BTAI and the impact of timing of repair on outcomes.

### **Methods:**

Using the National Trauma Databank, we identified adult patients with BTAI between 2012 and 2015. Patients with prehospital/emergency department cardiac arrest or incomplete datasets were excluded from analysis. The primary outcome evaluated was in-hospital mortality, and secondary outcomes included postoperative complications and overall length of stay. Multivariable logistic regression was performed to identify independent predictors of mortality

### **Results:**

A total of 5,811 patients were identified with BTAI, with 1,930 (33.2%) undergoing TEVAR, 111 (1.9%) open repair, and 3770 (64.9%) managed nonoperatively. In the patients undergoing TEVAR, 1,333 underwent early repair (within 24 hours of admission), 470 patients underwent delayed repair (beyond 24 hours from time of admission), and time to operative intervention was unknown in 127 patients.

In patients who underwent early TEVAR, in-hospital mortality was 3-fold greater compared to those who underwent delayed TEVAR {6.4% (84/1,333) vs. 2.1% (10/470),  $p < 0.05$ }. The median LOS was 17.5 days in the early repair group versus 22.0 days in the delayed group ( $p < 0.05$ ).

On logistic regression analysis (adjusted for ED hypotension, admission GCS  $\leq 8$ , ISS, and age  $\geq 65$ ), patients who underwent delayed TEVAR had a significantly lower mortality compared to those who underwent early TEVAR (adjusted odds ratio: 0.30; 95% CI: [0.15–0.60]; adjusted  $p$  value  $< 0.01$ ).

### **Conclusion:**

TEVAR is the primary operative approach in patients with BTAI. In patients with BTAI who underwent TEVAR, delayed repair after 24 hours was associated with a longer length of stay but significantly decreased mortality.

## THE PROGRESSION OF LOW GRADE BLUNT AORTIC INJURIES ON CT IMAGING

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**Introduction:** A high grade (grade 3, 4) blunt aortic injury (BAI) frequently requires intervention and is a major cause of mortality in trauma patients. The management of low grade BAI (grade 1, 2) is not well characterized. This study aims to review imaging strategies and injury progression in low-grade BAI.

**Methods:** We identified 10,178 blunt trauma patients, who underwent 7,661 chest CTs from 2013-2016. Charts for patients with any suspicion of BAI on initial CT were reviewed for demographics, initial aortic injury grade, concurrent injuries, chest abbreviated injury score (AIS), injury severity scores (ISS), initial and delayed intervention, timing of repeat imaging, ICU length of stay, and mortality. Subjects were then stratified by initial aortic injury grade. ANOVA and Chi-squared tests of significance were performed (IBM SPSS Statistics 25) to compare the above variables across initial aortic injury grade.

**Results:** From this cohort, 32 BAIs were identified. Patients were 79% male with a mean age of 36 (SD 16). The median ISS score was 39.5 (IQR 16.5-62.5) and chest AIS was 4 (3-5). Nine patients (28%) underwent initial intervention; 3 open (9%) and 6 endovascular (19%). Eighteen patients (56%) underwent initial non-operative intervention with repeat imaging. The median number of rescans was 1 (IQR 0-2), and the average hours passed from initial to the first repeat CT scan was 9.5 (SD 7.6). On repeating imaging, grade 1 BAI are more likely to resolve (67%) compared to grade 2-4 (0%,  $p=0.029$ ). Of patients who received repeat imaging, 9 (50%) required delayed intervention; 2 open (11%) and 7 endovascular (39%). Non-operative treatment was more likely in low grade injuries (41%) compared with high grade injuries (3%;  $p=0.003$ ). Average ICU length of stay was 6.6 days (SD 9.6). Overall all-cause mortality in patients with BAI was 6 (19%). Overall attributable mortality was 3 (9%). Attributable mortality for grade 1, 2, 3, and 4 injuries was 0%, 0%, 0%, and 27% respectively ( $p=0.097$ ).

**Conclusion:** No injuries showed progression on follow-up imaging, while Grade 1 injuries were more likely to resolve and not require intervention. Follow-up imaging is necessary for even low-grade injuries to determine stability.

TABLE 1. Treatment and Progression of Imaging in Blunt Aortic Injuries

Variable	Overall	Grade 1	Grade 2	Grade 3	Grade 4	<i>p</i>
Number of patients, n	32	13	5	3	11	
Initial intervention, n, (%)						
Open	3 (9)	0 (0)	0 (0)	0 (0)	3 (27)	0.097
Endo	6 (19)	1 (8)	0 (0)	1 (33)	4 (36)	0.183
Repeat CT	18 (56)	9 (69)	4 (80)	2 (67)	3 (27)	0.115
Repeat CT status, n, (%)						
Resolved	6 (33)	6 (67)	0 (0)	0 (0)	0 (0)	0.029
Stable	12 (67)	3 (33)	4 (100)	2 (100)	3 (100)	
Progressed	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	
Delayed intervention, n, (%)						
Open	2 (11)	1 (11)	0 (0)	1 (50)	0 (0)	0.268
Endo	7 (39)	2 (22)	1 (25)	1 (50)	3 (100)	0.103
Non-operative, n, (%)	14 (44)	9 (69)	4 (80)	0 (0)	1 (9)	0.003
All-cause mortality, n, (%)	6 (19)	2 (15)	0 (0)	0 (0)	4 (36)	0.242
Attributable mortality, n, (%)	3 (9)	0 (0)	0 (0)	0 (0)	3 (27)	0.097

## COMPARING A BLADED TROCAR DEVICE TO TRADITIONAL OPEN TUBE THORACOSTOMY FOR PNEUMOTHORAX IN A PORCINE MODEL

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**Introduction:** Correct and timely tube thoracostomy can be lifesaving for a battlefield pneumothorax. The ability to safely and reliably perform tube thoracostomy in the combat theatre would be of significant value. A bladed trocar system is a hand held device to facilitate proper tube placement and has been validated for relief of tension pneumothorax compared to needle decompression. We investigate whether the bladed trocar has a similar potential for treatment of simple pneumothorax compared to traditional open tube thoracostomy.

**Methods:** Pneumothoraces were created in 5 *in vivo* swine. Interventions were randomized to open thoracostomy (OT, n=25) versus bladed trocar technique (BT, n=25). Pneumothorax resolution, tube position, and incision size were evaluated by a blinded reviewer. Thoracoscopy was used to evaluate for iatrogenic injuries.

**Results:** Fifty chest tubes were placed with 25 in each cohort. Immediate pneumothorax resolution was seen in >95% of cases in each cohort. Mean insertion time did not differ between OT and BT groups ( $39.2 \pm 10.4$  seconds vs.  $37.7 \pm 17.1$  seconds;  $p=0.9$ ), but the BT required smaller incisions (2.7cm v. 3.5cm;  $p<0.05$ ). Injuries between the two groups showed no significant difference (n=2 vs. n=7;  $p=0.06$ ). The most common injury was violation of the visceral pleura (10%, n=5 for both groups).

**Conclusion:** The bladed trocar was equal in comparison to open thoracostomy in regards to insertion time, pneumothorax resolution, and injury rates. The bladed trocar required a smaller incision compared to open tube thoracostomy and may be a useful adjunct in simple pneumothorax management in the combat environment.

## A COMPARISON OF DRAINAGE AND PATIENT OUTCOME METRICS BETWEEN SMALL-BORE AND LARGE-BORE CHEST TUBES IN THE SETTING OF DELAYED HEMOTHORACES: A 7-YEAR, FIVE-CENTER STUDY

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**Introduction:** Large bore tubes (LB, >14Fr.) are the standard treatment for emergent hemothoraces (HTXs), but treatment of delayed HTXs remains variable. It remains unclear whether small bore (SB, ≤14Fr.) pigtail tubes have the same efficacy and ability to drain delayed traumatic hemothorax (HTX) as LB (>14Fr.) tubes. The goal of our study was to compare tube and patient outcomes between SB and LB analyze the drainage and patient outcomes of SB tubes in patients with delayed HTX. We hypothesized that SB tubes would be as safe and effective as LB tubes. **Methods:** This was a retrospective observational study across 7.5yrs at 5 Level 1 trauma centers across three US states. We included patients 1) diagnosed with a HTX, or multiple rib fractures with bloody effusion from chest tube; 2) with initial chest tube placed ≥36h of arrival. We excluded tubes placed for hemopneumothoraces. SB tubes were compared to LB tubes. The three primary outcomes were tube failure (requiring an additional/replacement tube or video-assisted thoracoscopy [VATS]), mean volume of drained fluid (mL), and rate of drained fluid (volume of fluid [mL]/hours). Secondary outcomes were tube complications (tube falling out or clogging, pleural empyema, pneumonia, retained HTX), time on chest tube, and in-hospital mortality. Patients could have had more than one tube in this study and possibly had bilateral tube placement. Dependent and independent analyses were used to assess primary and secondary outcomes. **Results:** There were 160 SB patients (191 tubes) and 55 LB patients (64 tubes). There were no significant differences between study groups in 13 demographic or injury characteristics. 25 patients had bilateral chest tubes. The median (IQR) tube size for each group was as follows: SB [12Fr. (12-14)] and LB [32Fr. (28-32)]. There was no significant difference in SB and LB groups in the amount of time each tube was in place (89 vs. 134 hrs,  $p=0.35$ ). The failure rate of SB tubes was significantly smaller than LB tubes (5% vs. 110%,  $p<0.001$ ). Mean (SE) volume of drained fluid was not significantly different SB vs. LB (767(345) vs. 636(221) mL,  $p=0.71$ ). Similarly, the median (IQR) rate of drained fluid was not significantly different between SB and LB (54 (31-210) vs 124 (35-392) mL/hr,  $p=0.36$ ). SB tubes clogged or fell out significantly more often than LB tubes (4% vs. 0%,  $p<0.001$ ); clogged SB tubes ranged from 10–14Fr, while those that fell out ranged from 8–14Fr. There were two cases of pleural empyema, both in the SB group. There was no significant difference between SB and LB tubes in rates of retained HTX (8% vs. 6%,  $p=0.79$ ), pneumonia (6% vs. 0%,  $p=0.08$ ), or returning to prior function (36% vs. 44%,  $p=0.31$ ). However, in-hospital mortality was significantly higher in LB vs. SB (8% vs. 1%,  $p=0.02$ ). **Conclusion.** While there is a perceived reluctance to use a SB tube to manage delayed HTX, our data indicate they are effective in draining a delayed HTX. SB tubes had a significantly smaller failure rate, and similar ability to drain fluid compared to LB tubes. Nevertheless, SB tubes were significantly more prone to clogging and falling out. These multi-center data lend support to the use of SB tubes for the management of delayed HTXs.

## IN FOR A PENNY, IN FOR A POUND: OBESITY WEIGHS HEAVILY ON BOTH COST AND OUTCOME IN TRAUMA

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**Introduction:** Obese patients are presumed to be at higher risk for complications after trauma, but the current literature offers mixed conclusions regarding the effect of increasing body mass index (BMI) on outcomes after trauma laparotomy. This study evaluated the impact of obesity on outcomes and cost in patients undergoing trauma laparotomy at a level I trauma center.

**Methods:** Data on all patients requiring trauma laparotomy from January 2016 to December 2016 were prospectively collected. Patients were stratified into non-obese (BMI < 30), obese (BMI 30-40), and morbidly obese (BMI > 40) groups. Multiple logistic regression analysis and multiple linear regression analysis were used to determine variables significantly associated with patient morbidity and length of stay.

**Results:** 313 patients underwent a trauma laparotomy: 225 (72%) non-obese, 69 (22%) obese, and 19 (6%) morbidly obese. Complications occurred in 97 patients (31%). There was no difference between the groups with respect to severity of injury or shock on presentation. However, obese and morbidly obese patients had longer intensive care unit (ICU) and hospital lengths of stay (LOS), more ventilator days, larger hospital cost, and a higher morbidity and mortality compared to non-obese patients (Table). Multiple logistic regression analysis and multiple linear regression analysis found increasing obesity to be an independent predictor for patient morbidity (OR 3.0, CI 1.7-5.2), ICU LOS ( $\beta = 2.8$ ,  $p=0.02$ ) and hospital LOS ( $\beta=7.4$ ,  $p<0.001$ ).

	Non-obese	Obese	Morbidly Obese
<b>Morbidity</b>	25%	42%	63%
<b>Hospital LOS (days)</b>	13	21	30
<b>ICU LOS (days)</b>	4	10	12
<b>Ventilator days</b>	3	8	11
<b>Hospital cost</b>	\$47,498	\$85,623	\$118,958
<b>Mortality</b>	6%	17%	6%

**Conclusions:** Morbidity, mortality, and length of stay increased with worsening obesity after trauma laparotomy. These discrepancies contributed to rising hospital costs and added burden for the trauma center.

## NEPHRECTOMY IS INDEPENDENTLY ASSOCIATED WITH INCREASED MORTALITY AFTER RENAL TRAUMA: AN ANALYSIS FROM THE NATIONAL TRAUMA DATA BANK 2007-2016

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**Introduction:** The vast majority of high-grade renal trauma can be managed conservatively; however, nephrectomy is still common in the acute management setting. When controlling for multiple patient and injury severity measures, we sought to determine if nephrectomy was associated with increased mortality within the National Trauma Data Bank (NTDB).

**Methods:** We identified renal trauma patients from NTDB from 2007-2016. We excluded patients <18 years old, mechanisms other than blunt or penetrating trauma, missing facility codes, severe head injuries (abbreviated injury severity (AIS) score 6 or 7), and death within 4 hours of admission. We performed conditional logistic regression analysis to determine if nephrectomy was an independent predictor of mortality controlling for: age, sex, race (Caucasian/non-Caucasian), ethnicity (Hispanic /non-Hispanic), mechanism of injury (blunt /penetrating), shock (systolic BP <90 on admission), blood transfusion (yes/no), Glasgow Coma Score (GCS), Revised Trauma Score (RTS), and Injury Severity Score (ISS). We did not control for renal AIS score because of concern over inaccuracies in the NTDB.

**Results:** We identified 62,987 renal trauma patients that met our inclusion criteria; 75.8% were male, and 82.6% had a blunt mechanism of injury. Nephrectomy was performed in 3,348 (5.29%). In patients undergoing nephrectomy, 569 (17%) died vs 3,467 (5.81%) in the non-nephrectomy group. On multi-variable logistic regression, nephrectomy was associated with 72% increased odds of death (OR 1.72, 95% CI 1.56-1.91). Other significant associations with death included: age, non-Caucasian race, penetrating mechanism, hypotension, blood transfusion, lower GCS, lower RTS, and higher ISS (table 1).

**Conclusion:** In the NTDB, nephrectomy is associated with 72% increased risk of mortality even after adjusting for demographic, injury characteristics, and multiple measures of overall injury severity. In many circumstances, nephrectomy cannot be avoided in the management of acute trauma; however, nephrectomy may impact overall survival and is imperative to be avoided when possible.

Table 1: Logistic regression model for predicting mortality in renal trauma patients

Variables	OR	95% CI Limit	P-Value
Age*	1.0332	1.032-1.035	< 0.001
Sex (male)	0.9705	0.902-1.045	0.425
Race (non-caucasian)	1.115	1.031-1.206	0.006
Ethnicity (hispanic)	0.970	0.947-1.176	0.332
Mechanism (penetrating)	1.355	1.223-1.503	<0.001
Hypotension	1.249	1.133-1.376	< 0.001
Blood transfusion	1.479	1.368-1.599	<0.001
Glasgow Coma Score (GCS)*	0.912	0.894-0.930	< 0.001
Revised Trauma Score (RTS)*	0.836	0.794-0.881	< 0.001
Injury Severity Score (ISS)*	1.049	1.046-1.051	< 0.001
Nephrectomy	1.724	1.557-1.909	< 0.001

\*Each 1-point increase in GCS improved survival by 8.8% and in RTS by 16.4%; each 1-point increase in ISS worsened survival by 4.9%; each year increase in age worsened survival by 3.3%

## **TIME FOR AN UPGRADE: NEW GRADING SYSTEM FOR BLUNT SPLENIC TRAUMA INCORPORATING ANATOMIC INJURY AND CONTRAST BLUSH**

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**Introduction:** The purpose of this study was to determine which grades (I-V) of injury have a significantly higher failure rate in the presence of contrast blush (CB). The results were then used to propose a new grading system that incorporates both anatomic injury and CB to more accurately define failures for nonoperative management (NOM).

**Methods:** All blunt splenic trauma (BST) patients presenting at a single institution over 11 year period were retrospectively reviewed. Demographics, grade of injury (AAST scale), number of patients that underwent NOM both with and without CB, and failures of NOM were analyzed. Patients that had operative intervention for hemodynamic instability and those that underwent NOM after angio-embolization (AE) for CB were excluded from the study. Failure rates were compared for each grade between patients with CB vs. those without. Statistical analysis was performed using Fisher's exact test.

**Results:** 539 hemodynamically stable patients were eligible for NOM. Of these 104 (19%) patients were excluded for AE for CB. The remaining 435 (81%) patients that underwent NOM were separated into two groups (NO-CB vs. CB) and failure rates were compared based on grade: (NO-CB vs. CB) I (1% vs. 0%,  $p=1$ ), II (2% vs. 0%,  $p=1$ ), III (3% vs. 67%,  $p=0.02$ ), IV (17% vs. 100%,  $p=0.16$ ), V (57% vs. 100%,  $p=1$ ). In the NO-CB group the failure rate for grade I-III was only 1-3% with no significant difference between the grades. However, both grade IV and V, had a significantly higher failure rates when compared to I-III for NO-CB group. Therefore, in the new grading system, for NO-CB patients, we can likely combine grades I-III but keep Grade IV and V separate. For the CB group, grades I-II rarely had CB while grades III-V had high failure rates with no significant difference between the grades (67-100%). The lowest failure rate of 67% for grade III with CB was higher than the failure rate of 57% for grade V without CB. This supports the need to modify the current anatomy based grading system to include CB. The following new grading system is therefore proposed (Figure 1). These modifications remove the complex measurements needed with the previous grading system to differentiate between grade I-III and provide more accurate failure rates to guide management decisions based on resources at each individual institution.

**Conclusion:** A new grading system that incorporates both anatomic injury and CB to more accurately define failures rates of NOM is proposed.

### **ZONE III REBOA PLACEMENT: ARE EXTERNAL LANDMARKS ACCURATE FOR PLACEMENT?**

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**Introduction:** Placement of a REBOA catheter in Zone III of the aorta for temporary control of pelvic hemorrhage in the hypotensive patient has grown in popularity. Appropriate balloon placement is traditionally confirmed with Xray or fluoroscopy, however external landmarks of the umbilicus and the xiphoid process have been used to approximate insertion distance. Although the use of external landmarks for zone I occlusion are well described, there is little data to validate the use of external landmarks for zone III occlusion and underestimation of catheter insertion distance with iliac artery inflation carries significant potential morbidity.

**Methods:** Using a human cadaver model, external measurements of common anatomic landmarks were made. With a start point of 2cm distal to the midpoint of the inguinal ligament, measurements included right and left groin to umbilicus (UMB) and groin to xiphoid (XIP). Bilateral groin cutdowns were performed and a 7F sheath was inserted into the common femoral artery 2cm proximal to the profunda femoral artery and an ER-REBOA© catheter inserted and inflated. A laparotomy was then performed and intravascular distance to the proximal (renal arteries) and distal-most (aortic bifurcation) aspect of Zone III recorded. Measurements were correlated to determine accuracy of external landmarks at predicting the internal landing zone.

**Results:** Bilateral groins of 21 cadavers were used resulting in 42 entries. The mean distance from the groin to the umbilicus ( $15.7 \pm 1.7$ cm) and the groin to the xiphoid ( $31.6 \pm 2.6$ cm) was similar on the right and left sides ( $p=0.60$  and  $p=0.55$ , respectively). Internally, the mean distance to the superior and inferior aspects of ZONE III were  $29.3 \pm 2.5$ cm and  $23.3 \pm 2.4$ cm, respectively, with no significant difference between right and left side ( $p=0.28$ ;  $p=0.60$ ), with an overall Zone III length of 6.0cm [2.5-9.5cm]. Using the p-tip to umbilicus measurement, the balloon on all catheters (42/42) would be placed below zone III by a mean distance of 7.8cm [3.5-13cm]. Using the p-tip to xiphoid measurement, 24% (10/42) of catheters would occlude at zone III, and 67% (28/42) would occlude at or distal to the aortoiliac bifurcation missing Zone III by a mean of 1.9cm [0.15-5.35cm].

**Conclusion:** The landing zone for Zone III REBOA placement is small and the current external landmark measurement of catheter tip to xiphoid process is poor at estimating safe balloon occlusion zone and results in iliac artery placement in 2/3 of patients. Using external landmarks alone for Zone III occlusion should be done with caution.

**TRUST THE FAST: CONFIRMATION THAT A POSITIVE FAST EXAM IS HIGHLY SPECIFIC IN OVER 1,000 PATIENTS WITH PELVIC FRACTURES**

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**Introduction:** Use of the Focused Abdominal Sonography for Trauma (FAST) exam in patients with pelvic fractures has been reported as unreliable. We hypothesized that FAST is a reliable method for detecting clinically significant intra-abdominal hemorrhage in patients with pelvic fractures.

**Methods:** All patients with pelvic fractures over a 10-year period were reviewed at a Level I trauma center. FAST exam results were compared with computed tomographic (CT) findings and/or findings at laparotomy. The predictive ability of FAST was assessed by calculating the sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) of the examination in this cohort. The FAST exam was considered “false negative” if findings at laparotomy indicated traumatic intra-abdominal hemorrhage. Likewise, the FAST exam was considered “false positive” if findings at laparotomy indicated no intra-abdominal hemorrhage or CT scan failed to demonstrate intra-abdominal fluid or injury. Hemodynamic Instability Scores (HIS) were calculated for all patients.

**Results:** 1460 patients with pelvic fractures and an initial FAST were reviewed; 1192 underwent FAST and either CT or operative exploration. Mean age was 42.7 ± 19.7 years and ISS was 17.8 ±

12.0. The sensitivity and specificity for FAST in this group of patients with pelvic

	Confirmed (+)	Confirmed (-)	Total Patients
FAST(+)	76	18	94
FAST(-)	46	1052	1098

fracture was 62.3% and 98.3%, respectively. The PPV and NPV were 80.9% and 95.8%, respectively. Of patients with a positive FAST and identified negative findings, 15 (83.3%) were confirmed with a negative CT scan, and 3 (16.7%) underwent laparotomy without findings of intra-abdominal hemorrhage. Of patients with a negative FAST exam and confirmed positive findings (46 patients, 3.5% of all FAST negative patients), all were identified at laparotomy. The specificity remained high regardless of HIS grade.

	Number	Percent
HIS Grade 0	1013	85.0
HIS Grade 2	47	3.9
HIS Grade 3	48	4.0
HIS Grade 4	41	3.4
HIS Grade 5	24	2.0
Data Unavailable	19	1.6

**Conclusion:** A positive FAST exam in a patient with a pelvic fracture is highly specific for intra-abdominal fluid. These data suggest that a positive FAST in this clinical scenario should be considered to represent intra-abdominal fluid. This series contradicts prior reports that FAST is unreliable in patients with pelvic fracture.

## HYBRID EMERGENCY ROOM SYSTEM (HERS) IMPROVES TIMELINESS OF ANGIOEMBOLIZATION FOR PELVIC FRACTURE

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**Introduction:** Timely angioembolization (AE) is well known to improve outcomes of patients with hemorrhage due to pelvic fracture. In July 2017, our institution installed a hybrid emergency room system (HERS) equipped with a computed tomography scanner, fluoroscopy, and operating room set-up. In the HERS, surgeons and interventional radiologists (IRs) can perform damage control surgery and AE simultaneously or subsequently. We hypothesized that the HERS improves the timeliness of AE for pelvic fracture.

**Methods:** A retrospective medical record review was performed for patients who underwent AE for pelvic fracture at our institution (4/2015–12/2018). Patients' demographics, the location of AE, the injury severity score (ISS), the revised trauma score (RTS), the probability of survival by the trauma and injury severity score (TRISS) method, the activation of a massive transfusion protocol (MTP), the presence of surgeons and IRs upon patient arrival, the time from arrival to AE, the type of procedures, and the in-hospital mortality rate were analyzed. These data were compared between patients who underwent AE in the regular angio-suite (Non-HERS group) and in the HERS (HERS group).

**Results:** In total, 96 patients met the inclusion criteria. The Non-HERS group comprised 72 patients, and the HERS group comprised 24 patients. Compared with the Non-HERS group, the HERS group had a higher incidence of MTP activation, simultaneous or subsequent surgery, and performance of resuscitative endovascular balloon occlusion of the aorta. Surgeons and IRs were more frequently present upon patient arrival in the HERS than Non-HERS group. The time from arrival to AE was shorter in the HERS than Non-HERS group. The time spent in the emergency room was longer in the HERS than Non-HERS group. There were no differences in the rates of infectious complications or in-hospital mortality between the two groups. Survivors in the HERS group had a higher ISS, RTS, and probability of survival by the TRISS method than survivors in the Non-HERS group (Table 1).

**Conclusion:** The HERS improved the timeliness of AE for pelvic fracture. More severely injured patients were able to survive in the HERS. Simultaneous or subsequent surgery could be performed in a timely fashion. The new team building involving the addition of IRs to the traditional trauma resuscitation team will enhance the benefit of the HERS. Further study is warranted to establish a standardized protocol for care of trauma patients in the HERS.

**Table 1.** Outcomes of patients who underwent angioembolization for pelvic fracture

	Non-HERS group (n = 72)	HERS group (n = 24)	P value
ISS	29 (9-57)	35 (17-57)	0.849
ISS in survivors	27 (9-57)	36 (17-57)	0.405
RTS	7.8 (0-7.8)	6.1 (2.6-7.8)	<b>0.012</b>
RTS in survivors	7.8 (2.6-7.8)	5.7 (2.6-7.8)	<b>&lt;0.001</b>
TRISS Ps, %	90 (1-99)	60 (1-98)	0.356
TRISS Ps in survivors, %	93 (1-99)	61 (1-98)	<b>&lt;0.001</b>
Massive transfusion protocol activation	23 (32%)	17 (71%)	<b>0.001</b>
Surgeons present on patient arrival	51 (71%)	22 (92%)	<b>0.030</b>
IRs present on patient arrival	15 (22%)	19 (79%)	<b>&lt;0.001</b>
Simultaneous or subsequent surgery	12 (17%)	13 (54%)	<b>0.001</b>
Surgery first	7 (64%)	1 (8%)	<b>0.006</b>
REBOA	8 (11%)	7 (29%)	<b>0.042</b>
Time to AE, minutes	103 (2-690)	46 (5-75)	<b>&lt;0.001</b>
AE time, minutes	65 (24-150)	53 (25-149)	0.719
Time spent in the ER, minutes	40 (17-186)	150 (30-343)	<b>&lt;0.001</b>
Infectious complications	8 (11%)	3 (13%)	0.553
In-hospital mortality	11 (15%)	3 (13%)	0.516

Data are presented as median (range) or n (%). ISS, injury severity score; HERS, hybrid emergency room system; RTS, revised trauma score; TRISS Ps, probability of survival by trauma and injury severity score method; IRs, interventional radiologists; REBOA, resuscitative endovascular balloon occlusion of the aorta; AE, angioembolization; ER, emergency room

## RISK FACTORS FOR DUODENAL REPAIR LEAK AFTER TRAUMA- A PANAMERICAN MULTI-CENTRIC TRIAL

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**Introduction:** Leak after repair of duodenal injury (DI) increases morbidity and mortality. We performed a secondary analysis of a retrospectively collected database conformed from 11 Panamerican Trauma Society centers to identify risk factors of leak after repair of DI.

**Methods:** Patients  $\geq 18$  years old with repair of DI from 2006 to 2017 were included. Deaths in the first 48 hours were excluded. Demographics, mechanism, injury severity, associated injuries, transfusions and type of repair were examined as potential risk factors for leak. Multiple logistic regression (MLR) modeling was used to identify independent risk factors for leak.

**Results:** A total of 308 patients were included. Penetrating trauma occurred in 234, (76.0%). Duodenal leak after repair developed in 52 subjects (16.9%). Compared to those without leak, patients with leak had significantly lower SBP at admission, higher ISS, higher abdominal AIS, and a higher proportion of AAST III, IV and V DI. Complex repair was performed more frequently in patients who leaked. Pancreatic and major vascular injury did not predict leak.

**Table. MLR analysis of independent risk factors of leak of duodenal repair.**

Variable	OR (95% C.I.)	p-value
Hypotension, SBP<90 mm Hg	3.108 (1.434 – 6.737)	0.004
Abdominal AIS	1.764 (1.205 – 2.583)	0.004
Duodenal AAST grade $\geq 3$	1.434 (1.011 – 2.034)	0.043
<b>Surgical treatment</b>		
Primary repair, (reference)	1	
Suture + duodenostomy	5.678 (1.957 – 16.473)	0.001
Complex repairs	5.572 (2.334 – 13.293)	<0.001
<i>Area under ROC curve = 0.810 (0.748 – 0.873)</i>		<i>Goodness of fit p = 0.298</i>

MLR identified hypotension, abdominal AIS, duodenal AAST severity  $\geq 3$  and type of repair as independent predictors (table).

**Conclusion:** Hypotension, severity of abdominal trauma and severity of duodenal trauma independently predicted leak. Primary repair with duodenostomy and more complex repairs were associated with significantly higher rates of leak compared to primary repair alone.

## CONTEMPORARY USE OF RESUSCITATIVE ENDOVASCULAR BALLOON OCCLUSION OF THE AORTA: ARE WE CHOOSING THE RIGHT PATIENT?

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**Introduction:** There have been conflicting reports on the patient outcomes by using resuscitative endovascular balloon occlusion of the aorta (REBOA) in trauma. While clinical indications for REBOA differ between institutions, it is typically indicated for non-compressible truncal hemorrhage (NCTH), and contraindicated for severe head, neck, and thoracic injuries as it can potentially increase blood loss. A large majority of earlier studies were performed at a single center and few at major Level 1 trauma centers. It remains unknown how REBOA is utilized in the United States. We hypothesized that REBOA might often be used for trauma patients for whom REBOA is not indicated.

**Methods:** This is a retrospective cohort study using the American College of Surgeons Trauma Quality Improvement Program (ASC-TQIP). We included patients who underwent REBOA from January to December 2016. We defined an appropriate REBOA candidate as a patient with: 1) abdominal organ injuries or pelvic fractures (AIS  $\geq$  3), and 2) no associated severe head, neck, face, or thoracic injuries (AIS  $\geq$  4). We compared patient demographics, injury severity and clinical outcomes between REBOA candidates and non-candidates.

**Results:** A total of 71 patients were included. Median age was 48 (IQR: 29-62), 73.2% were male. A large majority of patients sustained blunt trauma (88.7%) and median ISS was 29 (IQR: 21.5-40.5). A median time to REBOA use was 96 min (IQR: 39.8-261.7). Of those, 42 patients (59.2%) met the injury criteria for the use of REBOA. On the other hand, 29 patients (40.8%) were considered non-candidates. In-hospital and 24-hour mortality were significantly higher in the non-candidate group (62.1% vs. 31.0%,  $p=0.019$  and 27.5% vs. 11.9%,  $p=0.04$ , respectively).

**Conclusion:** Our data suggest that REBOA was often used for patients who did not meet the injury criteria currently recommended in the guidelines. The use of REBOA in non-candidates was associated with a significantly higher mortality.

Variables	Candidate group (n=42)	Non-candidate group (n=29)	p value
Median age (IQR)	45 (30-58)	50 (29-64)	0.38
Male sex (%)	34 (81.0)	18 (62.1)	0.08
GCS <9 (%)	10 (23.8)	16 (55.2)	0.008
RR >20 (%)	8 (19.0)	12 (41.4)	0.046
Median ISS (IQR)	28 (21-34)	36 (29-50)	0.007
Laparotomy (%)	13 (31.0)	10 (34.5)	0.96
Angioembolization (%)	14 (33.3)	10 (34.5)	0.90
Level 1 center (%)	27 (64.3)	16 (55.2)	0.71

**PROXIMAL ARTERIAL PRESSURE AND ASSOCIATED DISTAL BLOOD FLOW PATTERNS DURING RESUSCITATIVE ENDOVASCULAR BALLON OCCLUSION OF THE AORTA**

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**Introduction:** Resuscitative endovascular balloon occlusion of the aorta (REBOA) and partial REBOA (pREBOA) are novel adjuncts for noncompressible truncal hemorrhage. To date, distal blood flow during partial occlusion is poorly characterized. This study aims to compare proximal arterial pressure to distal aortic and visceral blood flow with standard REBOA and prototype partial REBOA devices.

**Methods:** Twenty Yorkshire swine (35-55kg) were randomized to normal physiologic conditions with zone 1 REBOA (nSR, n=5) vs pREBOA (nPR, n=5) or a 20% controlled hemorrhage and iliofemoral vascular injury with zone 1 REBOA (iSR, n=5) vs pREBOA (iPR, n=5). Distal aortic and superior mesenteric artery (SMA) flow, and proximal arterial pressures were monitored. Balloon occlusion was sequentially deflated in a stepwise fashion from complete occlusion (0L/min) to full aortic flow of 1L/min.

**Results:** Two iPR animals were excluded due to early demise from non-study factors. The nSR cohort displayed distal aortic to SMA flow ratios suggestive of significantly decreased SMA perfusion compared to nPR at all aortic flow rates (all  $p < 0.05$ ) (Fig. 1). In the hemorrhage cohorts, iSR displayed proximal arterial pressure to distal aortic flow ratios suggestive of a greater reliance on proximal pressures for downstream perfusion compared to iPR at all aortic flow rates (all  $p < 0.05$ ) (Fig. 2), with an equivalent reliance on proximal arterial pressure for visceral perfusion in both cohorts.

**Conclusion:** pREBOA demonstrated equivalent or superior distal blood flow profiles compared to its standard REBOA counterpart during normal and hemorrhagic shock conditions. Proximal arterial pressures may be used to predict distal aortic blood flow during resuscitation and pREBOA devices may be associated with favorable distal vascular response and fluid dynamics.

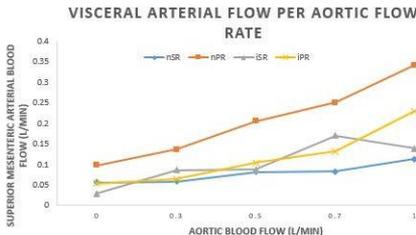


Figure 1 Superior mesenteric blood flow per aortic flow rates per each cohort. A linear relationship is noted for the hemorrhaged cohort: Flow =  $-.18(\text{aortic flow}) + 0.019$  ( $p < 0.001$ ,  $R = 0.585$ ,  $R^2 = 0.342$ ).

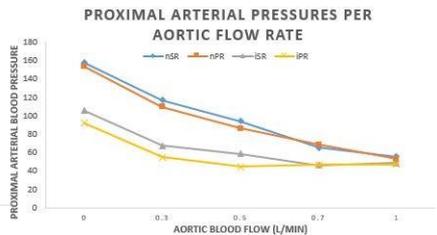


Figure 2 Proximal arterial blood pressures per aortic flow rates for each cohort. A linear relationship is noted for the hemorrhage cohort: Flow =  $-0.008(\text{proximal pressure}) + 1.922$  ( $p < 0.001$ ,  $R = 0.652$ ,  $R^2 = 0.425$ ) and the nonhemorrhage cohort: Flow =  $-0.006(\text{proximal pressure}) + 1.130$  ( $p < 0.001$ ,  $R = 0.804$ ,  $R^2 = 0.647$ ).

## **INITIAL EXPERIENCE IN MINIMALLY INVASIVE SURGERY IN DIAGNOSIS AND TREATMENT OF PENETRATING INJURIES**

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### **Introduction:**

In the last decades the minimally invasive approach has become the standard of care for elective abdominal and thoracic surgeries. However in penetrating trauma its use is still controversial due to the initially increased risk of missed injuries.

The aim of this study was to describe our initial results of a minimally invasive approach for thoracic and abdominal penetrating injuries.

### **Methods:**

Prospective study that included the first 50 patients operated between January 2017 and June 2018. Inclusion criteria were: penetrating abdominal or thoracic trauma, hemodynamically stable patients, trained laparoscopic surgeon available. Patients candidates to non operative care were excluded. All patients underwent preoperative CT scan. Perioperative data, surgery videos and 90-day follow up were analyzed.

### **Results:**

A total of 50 patients with penetrating trauma underwent a minimally invasive procedure during the study period, 94% were male. Thirty-two patients underwent a laparoscopic approach, 18 a video-assisted thoracoscopic surgery (VATS) and one patient had a combined abdominal and thoracic approach. Stab wounds (SW) accounted for 70% of the injuries.

In the laparoscopic group, 46.8% of the patients underwent a diagnostic laparoscopy and 46.8 underwent a therapeutic laparoscopy. Conversion rate was 6.2% mainly at the beginning of the series with no differences between SW and GSW. Therapeutic laparoscopies included diaphragm suturing, liver hemostasis, small bowel and gastric suturing, small bowel resection and anastomosis, colon repair and bladder repair. Average length of stay was 3.4 days (range 1-9). Two patients had complications, one managed endovascular and one reoperation because of a pararectal abscess.

In the VATS group, all patients underwent a therapeutic procedure, and 1 patient was converted to an open approach. The most common indication was hemothorax and most patients underwent hemostasis of the thoracic wall. Average length of stay was 3.8 days (range 2-8). No missed injuries were identified in this initial experience. No complications were identified during followup.

### **Conclusion:**

A minimally invasive approach can be utilized for hemodynamically stable patients. The adequate selection of patients and the presence of a trainee MIS surgeon is the key factor to positive results.

## ARE DECREASED RATES OF SPLENECTOMY FOR BLUNT SPLENIC INJURY JUSTIFIED?

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**Introduction:** Non-operative management (NOM) of blunt splenic injury (BSI) and the use of splenic angioembolization (SAE) has increased over time. A recent National Trauma Data Base study showed splenectomy is performed in 24% of patients with high-grade BSI. Our goal is to quantify changing trends in the management of BSI at our institution. We hypothesize the rate of splenectomy for BSI continues to decrease.

**Methods:** We identified patients (pts) with BSI  $\geq$  16 years old from 2012 to 2017 using our institutional trauma registry. After IRB approval, medical records were reviewed for demographic information, AAST splenic injury grade, volume of hemoperitoneum, presence of contrast blush, management strategy, admission systolic blood pressure (SBP  $<$ 90), injury severity score (ISS) and survival. CT scans were reviewed by radiologists blinded to care to assign injury grade, hemoperitoneum volume and contrast blush. Management strategy was characterized as operative (splenectomy, splenorrhaphy or laparotomy only) versus non-operative (NOM) (with SAE considered an adjunct to NOM). Failure of NOM was defined as surgery, either splenectomy or splenorrhaphy, or death from hemorrhage after initial intention to treat non-operatively. Age  $>$  55, AAST Injury Grade, ISS, SBP  $<$  90, and/or presence of large hemoperitoneum on CT scan were analyzed for association with splenectomy. We utilized binary logistic regression procedures to calculate odds ratios to determine the effect on splenectomy rate.

**Results:** 325 pts with BSI were identified. Ages ranged from 16 to 101 (mean: 41) with 26% of pts  $\geq$ 55 years of age. AAST injury grades were as follows: I-87; II-104; III-65; IV-45; V-13. Eleven pts were not imaged and went directly to the OR. The ISS ranged from 4 to 75 (mean 22). 28 pts (8.6%) presented with SBP  $<$ 90 or MAP  $<$ 60. A contrast blush was present on CT imaging in 82 (25%) pts. Large volume hemoperitoneum was present in 109 (33%) pts. Successful NOM was achieved in 89.8% of pts, with 15.8% of these pts undergoing SAE. Splenectomy was performed in 7.7% of pts with BSI; 3.4% underwent urgent splenectomy without imaging and 4.3% underwent splenectomy after CT imaging. Nine pts (3.1%) failed NOM; seven of these pts proceeded to splenic surgery while two died (ISS 12 and 17). The overall mortality rate for all pts with BSI was 6.4%. Splenectomy was most common in grade IV or V BSIs (6.7% and 15.4%). SAE was utilized frequently for high grade injuries (IV and V) with 46.7% of grade IV injuries and 69.2% of grade V injuries undergoing SAE. Factors significantly associated with splenectomy were AAST Injury Grade ( $p=.009$ ), ISS ( $p=.001$ ), and SBP  $<$  90 ( $p=.010$ ). When controlling for all variables, however, enlarged hemoperitoneum was the only significant predictor in the full model (OR=3.086,  $p=.028$ ). Stepwise procedures revealed enlarged hemoperitoneum (OR = 3.745,  $p=.005$ ) to be the main predictor of splenectomy, controlling for ISS (OR=1.034,  $p=.043$ ).

**Conclusion:** The rate of open splenectomy for BSI continues to decrease compared to historical controls. The strongest association with the need for splenectomy was large hemoperitoneum. This may indicate that large hemoperitoneum strongly influences the decision to proceed with surgery in stable BSI pts. BSI is more commonly managed with NOM and SAE at our institution even in pts with high-grade BSI. Our data suggests the trend towards increased NOM is safe and effective given the low rate of failure of NOM and mortality.

**SALT IN THE WOUND: DRIER PATIENTS, AND FASTER FASCIAL CLOSURE AFTER PENETRATING ABDOMINAL INJURY**

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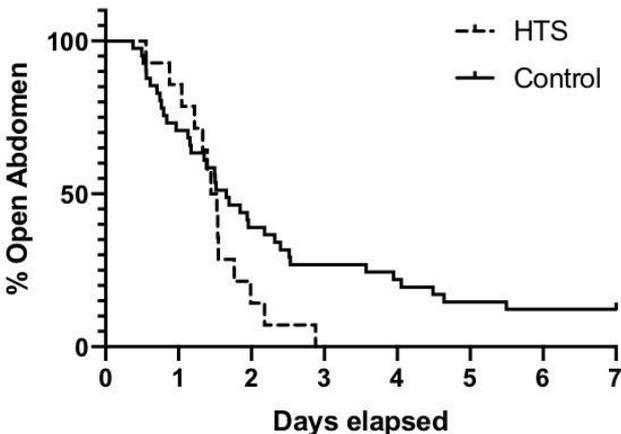
**Introduction:** Hypertonic saline (HTS) improves primary fascial closure (PFC) rates in unselected injured patients undergoing damage control laparotomy (DCL). Previous reports have not specifically investigated those requiring DCL after penetrating abdominal trauma. Higher rates of operative management in this population make it ideal to study the effects of HTS. We hypothesized HTS infusion results in an improved PFC rate, decreased time to PFC, and reduces total crystalloid volume at the expense of sodium loading.

**Methods:** We retrospectively analyzed all penetrating abdominal injury patients undergoing DCL (January 2015 to December 2018). We compared patients who received 3% HTS at 30 ml/h to those only receiving isotonic fluid resuscitation while the fascia was open. Intergroup comparisons were by ANOVA and Tukey’s comparison, students *t*, and Chi square tests.

**Results:** Fifty-five patients (pt) underwent DCL (HTS =14 pt, isotonic fluid =41 pt). Age (35.4 yrs v. 33.5 yrs,  $p=0.6797$ ), gender (100% v. 97.6% male,  $p=>0.999$ ), and ISS (32.6 v. 25.25,  $p=0.5611$ ) were similar between groups. More HTS patients achieved PFC (100% v. 73.5%;  $p = 0.021$ ) within 3 days. PFC was achieved more rapidly in HTS (36.49 hrs v. 59.05 hrs;  $p = 0.0127$ ) (Figure 1). Mean 24-hour fluids were significantly less in HTS (5.2L vs. 8.6L,  $p= 0.0129$ ), reducing total body water by 3.4L. Peak sodium (Na) mEq/L and DNa during the first 72 hours were increased in the HTS group (146 v.142,  $p=0.0016$ , 5.1 v. 2.3,  $p=0.016$ ).

**Conclusion:** HTS significantly reduces time to PFC and total crystalloid volume over 24 hours but did so at the expense of increased 72 hours Na concentration. Reduced total body water may underpin successful PFC and is a controllable element during resuscitation and DCL management.

**Time to PFC**



## **Early Health and Social Outcomes are Demonstrated for Participants in Hospital Based Violence Intervention Programs**

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### **Introduction:**

Recidivism is usually reported as the measure of success for Hospital Based Violence Intervention Programs (HVIPs). However, recent literature suggests time to re-injury to average 4 years. 30 HVIPs are exclusive sustained by funding that is renewed annually and cannot practically be expected to report a recidivism in that time. Early outcome successes are predictive to HVIP success (housing, employment, and mental health), therefore we suggest that reporting early health outcomes creates a mechanism for nascent programs to report their successes. The purpose of this study was to report the early positive outcomes of a nascent HVIP.

### **Methods:**

The case management records of a nascent HVIP were reviewed from July 2017-December 2018. Patients demographics and reported needs at initial evaluation were evaluated. The attainment of these needs at the time of study completion is reported. Subset analysis was performed on individuals who “completed” the HVIP.

### **Results:**

120 patient records were reviewed. 11 (9%) were lost to follow up after program consent. On intake, 24 (20%) reported a need for further education, 64 (53%) were in unstable housing situations, 95 (79%) were unemployed or underemployed, 109 (91%) were uninsured or underinsured for healthcare, 37 (31%) required assistance with the criminal justice system and 98 (82%) reported a need for mental health services. Alcohol abuse was identified in 1.7% of enrolled patients and illicit drug use in 24% of patients, 80% of which was isolated marijuana use. 50% of enrollees were scored as "moderate risk" or "high risk" by initial case worker assessment.

Ninety (75%) patients received information or referral, 102 (85%) obtained personal advocacy and 54 (44%) successfully applied for Victims of Crime Compensation funds. Of the initially identified needed services, 7 (29%) achieved education goals, 23 (35%) obtained stable housing, 13 (14%) became employed, 19 (17%) obtained health insurance, 13 (35%) obtained assistance with the criminal justice system and 65 (66%) obtained mental health services. Seventeen (11%) of participants completed the program when all personal goals were attained. Nine (53%) had more than one accomplishment. The accomplishments were: gaining employment (n=10, 59%), finishing high school, trade school or GED (n=7, 41%), enrolling in mental health services (n=10, 59%), and obtaining health insurance (n=4, 23.5%).

### **Conclusions:**

HVIPs have been reported to decrease recidivism, but this metric may be imperfect as it can depend on ecological factors. Recidivism is difficult to capture both temporally and geographically, particularly for new programs. We suggest that early outcomes may be a better outcome measure for HVIPs and report such outcomes of a nascent HVIP. A longitudinal study linking early outcomes to decreased recidivism is needed, and a multicenter outcomes study is needed to provide benchmarking for program quality assessment.

**POSTER #22-WITHDRAWN**

## TRAINING ON A VIRTUAL REALITY CRICOTHYROIDOTOMY SIMULATOR IMPROVES SKILLS AND TRANSFERS TO A SIMULATED REAL-WORLD PROCEDURE

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**Introduction:** Cricothyroidotomy is a last resort emergency procedure for patients who cannot be intubated by conventional means and would otherwise face impending death. This procedure is done infrequently and training is needed for teaching and retention of the skill set. Currently, training is based on mannequin or animal models, which cannot simulate difficult airway situations. The Virtual Airway Skill Trainer (VAST-CCT) is a virtual reality simulator that was developed to train in the cricothyroidotomy procedure. The goal of the study is to test the effectiveness of training and transfer of skills of the VAST-CCT.

**Methods:** The study was a between subjects design with two groups, control and simulation. Subjects in the control condition did not receive any training on the task, while those in the simulation received training for ten sessions on the task over a period of two weeks. The subjects performed four critical steps in cricothyroidotomy on the simulator including 1) identifying landmarks, 2) making incision on the skin, 3) puncturing and dilating the cricothyroid membrane, and 4) intubation.

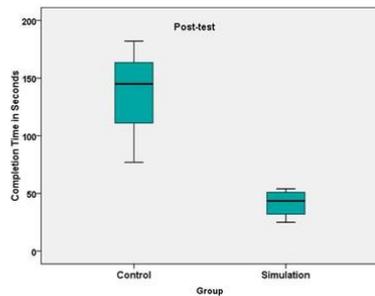
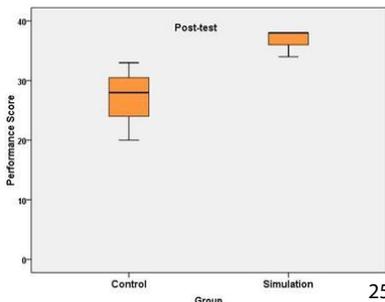
Proficiency based training model was used with subjects demonstrating proficiency score for at least two consecutive repetitions at each training session. Two expert trauma surgeons repeated the task on the simulator for five times to compute the proficiency benchmark. At the beginning of the study, both groups performed the task once on the simulator (pre-test) after which the simulation group commenced their training. Two weeks later, both groups performed the task once on the simulator (post-test) and twice on the TraumaMan (Simulab inc.) mannequin to demonstrate the transfer of skills. Subjects' performance was automatically recorded on the simulator, which included a performance score computed based on the accuracy of performance on the four tasks (maximum of 40) and completion time in seconds.

Subjects performance on the TraumaMan was evaluated using checklists, task completion time and intubation quality.

**Results :** The proficiency score based on experts (n=2) performances was  $(34 \pm 4)$ . A total of n=7 subjects (control = 3, simulation = 4) participated in the study. Paired samples t-test between pre and post-tests showed significant difference for the simulation group on both time ( $235.25 \pm 93$  vs  $41.5 \pm 12.6$ ,  $p = 0.021$ ) and score ( $15 \pm 9.6$  vs  $37 \pm 2$ ,  $p = 0.03$ ). No differences in performance was found for the control group for time ( $145 \pm 54.5$  vs  $134.6 \pm 53.2$ ,  $p = 0.115$ ) and score ( $31.3 \pm 1.5$  vs  $27 \pm 6.5$ ,  $p = 0.34$ ). Between group analysis using an independent samples t-test showed significant differences at the post-test for both time (control =  $134.6 \pm$

$53.2$  vs simulation =  $41.5 \pm 12.6$ ,  $p = 0.018$ ) and score (control =  $27 \pm 6.5$  vs simulation =  $37 \pm 2$ ,  $p = 0.032$ ). Analysis of performance on the mannequin showed that the simulation group performed better on intubation calculated based on the endotracheal tube insertion depth than the control group (control =  $1.6 \pm 2.6$  vs simulation =  $8.1 \pm 3.7$ ,  $p = 0.003$ ).

**Conclusion:** The results from even a small sample size clearly shows the effectiveness of VAST-CCT in training various steps of the cricothyroidotomy procedure as well the transfer of skills to real-world situation as demonstrated by performing on the TraumaMan mannequin



**THE BURDEN OF THE UNHELMETED MOTORCYCLIST ON A STATE WITHOUT A UNIVERSAL HELMET LAW: A PROPENSITY SCORE ANALYSIS**

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**Introduction:** Although helmets are associated with reduction in both mortality and cost of care of motorcycle collisions, many states, including Arizona, have failed to adopt universal helmet laws for motorcyclists, in part on the grounds that much of the existing research is limited by study design (eg. historical controls) and confounding variables. The goal of this study was to evaluate the statewide impact of helmet use in motorcycle collisions on hospital charges and mortality in trauma patients with propensity score analysis.

**Methods:**Motorcycle collision data from the Arizona State Trauma Registry from 2014-2017 were propensity score matched by regressing helmet use on patient age, gender, race, alcohol intoxication, illicit drug use, and comorbidities. Linear and logistic regression models were used to evaluate the impact of helmet use.

**Results:**Our cohort included 5,292 adult patients consisting of 2,646 propensity matched pairs. The cohort was 87.1% male with an average age of  $42.4 \pm 15.6$  years. There were not significant between group differences for patient age ( $P=0.771$ ), gender ( $P=1.000$ ), race ( $P=1.000$ ), alcohol intoxication ( $P=1.000$ ), illicit drug use ( $P=1.000$ ), the presence of one or more comorbidity ( $P=0.826$ ), or injury severity score ( $P=0.076$ ). Helmeted patients were less likely to be admitted to the ICU (20.6% vs. 24.2%, OR 0.81[0.71 - 0.92]) or be ventilated (7.3% vs 12.1%, OR 0.57[0.47 - 0.69]). Propensity matched analyses demonstrated helmet use to be associated with a 10.9% decrease in hospital charges ( $B=0.12$  [-0.18 - -0.05]) and a 56% decrease in mortality (OR 0.44 [0.33 - 0.60]).

**Conclusion:**In a state without mandated helmet use for all motorcyclists, the burden of the un-helmeted rider is significant with respect to lives lost and healthcare costs incurred. Although the helmet law debate with respect to civil liberties is complex and unsettled, it appears clear that helmet use is strongly associated with both survival and less economic encumbrance on the state.

## **URBAN GUN VIOLENCE: PARTNERING WITH LAW ENFORCEMENT TO UNDERSTAND THE EPIDEMIC**

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**Introduction:** Gun violence represents 10% of trauma admissions at our urban level 1 trauma center. Self-defense, hunting, and sport are primary reasons for gun ownership (Gallup 2013), but data on the circumstances of gunshot wounds (GSWs) is scarce. To inform fact-based conversations, we partnered with police to identify official circumstances of GSWs and health resource allocation. Criminal recidivism and factors related to suspect identification were also evaluated.

**Methods:** Police and court records were reviewed to identify GSWs in our city in 2015. Demographics, criminal history, and circumstances of gun use were recorded. Registry data for GSWs treated at our level 1 center was used for injury characteristics, outcomes, and hospital costs. Bivariate analysis identified victim factors associated with suspect identification.

**Results:** Manual review of 30,000 archived police records identified 688 GSWs. Lawful self-defense or accidents accounted for 2% with only 4 self-defense cases. Of the 423 GSWs (61%) treated at our center, 44% were admitted and 29% required operation. Emergency room only costs averaged \$12,500 vs. \$28,000 per admission, a burden of \$12 million for the city.

Prior charges were noted in 62% of victims; 38% had future charges, and 32% had both prior and future charges. Suspects were named in only 23% of cases and only 40% of those suspects received convictions. Suspects had prior charges in 55% of cases; 23% had future charges and 17% had both. Victims with prior records (17% vs 22%  $p=0.047$ ), male gender (18% vs 31%  $p=0.006$ ), black race (18% vs 33%  $p=0.007$ ), and injury severity score less than 15 (15% vs 35%  $p<0.001$ ) had fewer suspects identified.

**Conclusion:** The circumstances of urban GSWs do not correlate with stated reasons for gun ownership. Gun violence represents a potentially preventable injury but appears resistant to current legal interventions as evidenced by low suspect identification and criminal recidivism.

## **STOP THE BLEED: REPORT ON A STATE-WIDE BLEEDING CONTROL PROGRAM FOR THE PENNSYLVANIA STATE POLICE**

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**Introduction:** The Stop the Bleed (STB) program was initiated in 2015 as a result of the Hartford Consensus and has been promulgated nationally as a life-saving course to prevent death from hemorrhage. State Police officers are frequently immediate responders at the scene of an injury providing life-saving first aide to control hemorrhage, prior to EMS arrival. This study sought to examine the comfort level and knowledge of Pennsylvania (PA) State Police officers (PSP) in correctly instituting STB techniques as part of a standardized statewide educational initiative provided by trauma centers (TC) in PA in partnership with the leadership of the PSP and PA Trauma Systems Foundation.

**Methods:** Standardized STB courses were administered by 32 PA TC during an eight-month period in 2018 to all PSP officers utilizing a standardized curriculum with administration of questionnaires prior to and immediately following the training. Classroom and hands-on instruction consisted of teaching principles of hemorrhage control including direct pressure and tourniquet application. Each PSP officer received a free tourniquet as part of the training. Basic demographic information was collected on gender, age, prior tourniquet training and whether tourniquets had ever been applied. Data analysis consisted of chi-square analysis and McNemar Change tests for pre and post training results. A dependent t-test was calculated on the total score which was the sum of each of the seven training items giving a single point for each item answered correctly.

**Results:** 4200 State Police were educated by 32 TC. Pairs of pre and post education questionnaires were collected from 1,287 PSP officers undergoing STB education during the training period. Of this sample, 91.5% were male, and mean age was  $37.1 \pm 8.37$  with a range of 22 to 62 years of age. Of the sample, 65.5% had received prior training in tourniquet use and 10.7% had used a tourniquet before this training. Statistically significant gains in education were shown pre to post education on five of seven items including: *Where should a tourniquet be placed with respect to the bleeding source?* ( $p < 0.001$ ), *How much slack should be present, before tightening the windlass?* ( $p < 0.001$ ), *How many twists of the windlass should be used?* ( $p < 0.001$ ), *Life threatening bleeding is described as all of the following EXCEPT ...?* ( $p < 0.001$ ) and, *Before offering help to an injured patient you must...?* ( $p < 0.001$ ). A trend to significance was shown for one item: *Bleeding Control can be obtained by...?* ( $p = 0.055$ ). The overall gain in average number of correct responses was statistically significant ( $p < 0.001$ ) from pretest ( $4.03 \pm 1.39$ ) to posttest ( $5.63 \pm 1.03$ ). Prior to training, 58.2% of respondents felt “Extremely” or “Somewhat comfortable” applying a tourniquet and after training 99.1% reported they would now be “Extremely” or “Somewhat comfortable” applying a tourniquet ( $p < 0.001$ ).

**Conclusions:** Stop the Bleed education conducted in a statewide program administered by TC to PSP officers increased the comfort level of officers in applying tourniquets and understanding principles of bleeding control techniques. The feasibility of providing high quality, standardized training to a large group of immediate responders across a large geographic area was demonstrated. Further research is recommended in studying long term retention of information and whether the education proved useful in controlling hemorrhage in actual bleeding patients.

## MASS CASUALTY INCIDENT (MCI) SIMULATION WITHOUT MASS EXPENDITURE: A NOVEL MCI CURRICULUM FOR TEACHING RESIDENTS CORE CONCEPTS OF DISASTER MANAGEMENT

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**Introduction:** Mass casualty incidents (MCIs), both conventional and terrorist, are becoming more common in the US. During general surgery residency, there is a lack of formal training on the principles of disaster management required to effectively triage and treat patients during a MCI. We developed a 2-hour long MCI session including simulation geared towards filling the aforementioned training gap.

**Methods:** Our MCI session consisted of: 1) a 30 minute didactic session reviewing core disaster management principles, including triage, 2) a tabletop mass shooting simulation and 3) a debriefing. Prior to the session, participants took a pre-test assessing for prior training and experience as well as confidence with basic disaster management principles. For the simulation, surgical residents worked in groups to assess paper patients in a multi-staged triage and treatment simulation, needing to accurately triage patients using START criteria prior to advancing the patient to the next tier of care. This was followed by a post-test to assess for an increase in confidence as well as to solicit feedback on the quality of the session. Pre- and post-test scores for the self-assessment component were analyzed using a Wilcoxon signed-rank test with a p-value <0.05 considered significant.

**Results:** Thirty PGY 1 and 2 residents participated over 2 sessions. Background experiences varied: half rotated on a trauma service as students and/or as residents. Seven percent of individuals had prior EMT training, while 20% had prior disaster management or MCI training. Seven percent had participated in patient triage during an actual MCI. During the 2 simulations, a total of 159 triage decisions were made. Of those, 84% were correct. There was a 7% under- and 9% over-triage rate. All participants showed a significant increase in confidence regarding principles of MCI management (Table). All participants scored the simulation  $\geq 4$  on a 5 point Likert scale for being both valuable and engaging.

**Conclusion:** This tabletop MCI simulation is an effective method of teaching residents the core disaster management principles needed to effectively navigate a MCI, with triage rates comparable to published standards and an increase in confidence with these principles. Furthermore, it is inexpensive and easy to implement within any residency curriculum, affording training programs a unique tool to teach trainees critical skills for managing patients during a disaster.

	Median score (IQR)		
	Pre-Test	Post-Test	p-value
I can define or describe what a MCI is.	4 (3-4)	5 (5-5)	< 0.00001
I can describe the goals of providing adequate patient care during a MCI (ex. triaging patients).	3 (2.25-4)	5 (4-5)	< 0.00001
I feel comfortable triaging patients during a MCI.	2 (2-3)	4 (4-4)	< 0.00001
I am aware of the other institutions in my community that can provide patient care during a MCI.	2 (1.25-3)	4 (4-5)	< 0.00001
I am aware of how different CAPABILITIES of different institutions (ex. hospitals) in a community can influence triage decisions in order to provide optimal patient care.	3 (2-4)	5 (4-5)	< 0.00001
I can define and/ or describe the principal of surge capacity.	2 (2-3)	5 (4-5)	< 0.00001

\*Strongly Disagree=1, Somewhat Disagree=2, Neutral=3, Somewhat Agree=4, Strongly Agree=5

**INCIDENTAL, BUT NOT INCONSEQUENTIAL: A METHOD TO IDENTIFY AND TREAT INCIDENTAL FINDINGS IN ACUTE CARE SURGERY**

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**Introduction:** Ubiquitous utilization of computed tomography in acute care surgery has led to the inevitable identification of incidental findings. Focus on immediate care needs has the propensity to allow incidental findings to be ignored, potentially resulting in lost opportunities to intervene. We aimed to develop a method to efficiently triage and address incidental findings (IFs) in acute care surgery.

**Methods:** Nurse clinicians tracked IFs through routine review of imaging for all patients admitted to, or seen in consultation for trauma and emergency surgery at our tertiary care facility over the course of one year. Incidental findings were identified and classified as Level 1 (inpatient management), Level 2 (outpatient follow-up), or Level 3 (no follow-up necessary). Patients were notified prior to discharge, and given recommendations for further treatment. When appropriate, follow-up appointments were launched within the system. Telephone follow-up was then completed within 3-6 months to ensure findings were addressed.

**Results:** 1147 patients were included. 622 incidental findings were identified in 389 (33.9%) patients. Formal notification of IFs was completed in 370 (95.1%) prior to discharge, and 33 (8.5%) received additional notification by mail. Level 1 findings were identified in 41 (10.5%) patients. The largest number of IFs were Level 2 (282, 72.5%). Level 3 findings were identified in 66 (17.0%). Degenerative bone disease (92, 14.8%), hernias (93, 15.0%), and solid organ cysts (12., 19.8%) were the most commonly identified findings. 105 (16.9%) neoplastic processes were identified, including 34 adrenal, 18 thyroid, and 27 other solid organ masses. Phone call follow-up was attempted in all patients, and completed in 288 (74.0%) patients, of which 161 (55.9%) had followed-up on recommendations. Level 1 and 2 recommendations were more likely to be completed (46.3% vs. 42.9% vs. 31.8%, p 0.01) 26 (9.0%) had expired by the time of telephone follow-up. The percent of patients who complied with recommendations was not affected by initial notification method (written vs. verbal vs. mailed, p 0.11). Those who did not adhere to recommendations, received additional formal communication via mail as a secondary reminder. 23 patients, 21.9% of those identified with a neoplastic process, had either undergone surgical resection or medical therapy at time of follow up.

**Conclusion:** Most incidental findings require a form of follow-up. A methodical process for identification and patient notification of incidental findings in acute care surgery can reach beyond the acute phase, and positively impact care for patients with undiagnosed and potentially lethal medical problems. Recommendation compliance is unaffected by method of initial communication.

## The Limitations of Hospital and Law Enforcement Databases in Characterizing the Epidemiology of Firearm Injury.

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**Introduction:** Comprehensive data regarding the epidemiology of firearm injury in the United States do not exist. Current estimates extrapolate data predominately from inpatient hospital or law enforcement databases but both databases in isolation have limitations and exclude certain subgroups of patients. We hypothesized that a comprehensive effort to include inpatient, outpatient, and law enforcement data would more accurately describe the burden of firearm injury in our county.

**Methods:** We constructed a collaborative database merging firearm injuries (Jan 2017 to Dec 2018) including all patients admitted to the hospital, patients treated and released from the hospital (outpatient), and law enforcement from our county. Outcomes and injury patterns from individual databases were then compared to those of the collaborative database. Chi square analysis was performed.

**Results:** The trauma registry, total hospital (registry and outpatient) and law enforcement databases failed to include 54, 22 and 16 percent of all firearm injuries respectively when compared to the collaborative database. The hospital encountered 94% of survivors but failed to detect a third of non-survivors whereas law enforcement encountered 94 % of non-survivors but failed to include 20% of survivors. Two percent of injuries were managed at non-trauma centers. Cause of injury and mortality were significantly different dependent upon which database was utilized, ranging from 10% (hospital) to almost 30% from law enforcement.

Database Comparison							
	Registry		Hospital		Law	Collaborative	
Total Patients	492		838		895	1076	
<b>Cause of Injury (% Total)</b>							
Assault	80.5	NS	79	NS	82.3	<.05	76.4
Accidental	9.6	NS	11.7	NS	7.4	<.05	10.5
Intentional Self-inflicted	7.9	NS	4.7	<.05	9.4	NS	9.6
<b>Failed Injury Detection Rate</b>							NA
<b>All Patients</b>	54.3		22.1		16.8		NA
<b>By Survival</b>							
Survivors	49.9		6.3		20.3		NA
Non-survivors	66.8		66.8		6.1		NA
<b>By Cause of Injury</b>							
Assault	51.8		19.5		10.1		NA
Accidental	58.5		13.3		41.6		NA
Intentional Self-inflicted	62.2		61.2		18.4		NA
<b>Mortality by Database</b>							
Mortality (% Dead)	17.3	<.05	10.1	<.05	27.7	NS	24.5
Assault	14.4	<.05	8.6	<.05	22.4	NS	20.9
Accidental	2.1	NS	1	NS	3	NS	1.8
Intentional Self-inflicted	56.4	<.05	55	<.05	90.5	NS	82.5

**Conclusion:** The utilization of hospital or law enforcement databases alone do not accurately reflect firearm injury epidemiology and may misrepresent areas in need of greater injury prevention efforts. Mortality differs significantly dependent upon database. Collaboration to include hospital and law enforcement data sources is critical to accurately describe the societal burden of firearm injury.

## VERIFYING STOP THE BLEED™ SKILLS: EVALUATING INSTRUCTOR CONSISTENCY

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**Background:** Stop the Bleed is a national initiative to teach hemorrhage control skills (tourniquets and wound packing) to the lay public. There are currently no standards to assess whether Stop the Bleed™ participants are performing these skills correctly upon completion of training.

**Methods:** Using SMARTER methodology we created checklists of skill completion guided by criteria from Tactical Combat Causality Course for two separate hemorrhage control skills: tourniquet application and wound packing. The tourniquet application assessment was constructed using seven tasks across two latent dimensions including verbal communication (3 tasks) and tactile (4 tasks). The wound packing assessment was constructed with six tasks across the same dimensions: verbal communication (3 tasks) and tactile (3 tasks). All tasks were measured using a binary scale where 0 = “Not Observed/Failed to Perform Correctly” and 1 = “Observed/Performed Correctly.” Five videos were created for each skill demonstrating a range of appropriate skill completion from a control to multiple missing components. Seven experienced Stop the Bleed™ instructors evaluated each video. Initial measures of evaluator consistency were estimated using Fleiss’ Kappa to assess the reliability of agreement among instructors.

**Results:** Seven evaluators completed all assessments for ten videos. Evaluator background ranged from paramedic to physician. Kappa values ranged from 0.51 to 1.00. Correlation for the control videos was good at 0.90 and 1.00. For the remaining videos except one, kappa values ranged from 0.51 to 0.62.

**Conclusion:** Notable heterogeneity exists in evaluation of Stop the Bleed™ skill assessment even when a checklist is utilized. The need for a comprehensive and valid instrument to evaluate the skill transfer acquired during hemorrhage control education.

## ADOLESCENTS: BIG KIDS OR SMALL ADULTS? AN ANALYSIS OF ISOLATED SPLENIC INJURIES USING THE TRAUMA QUALITY IMPROVEMENT PROGRAM (TQIP) DATABASES.

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**Introduction:** Adolescents are a unique patient population. Physically they often look like adults, but physiologically and psychologically they may be more similar to younger children. Current literature demonstrates that injured children have improved outcomes when treated under pediatric specific protocols; likewise studies in adults show improvement in outcome when targeted guidelines are followed. In this study we sought to examine the characteristics, treatments and outcomes of isolated splenic injuries in adolescent trauma patients and compare them to younger children and adults.

**Methods:** A retrospective review of the Trauma Quality Improvement Program (TQIP) and the Pediatric TQIP databases was performed for the years 2014-2015. Patients with a diagnosis of isolated splenic injury were identified. Variables, including demographics, mechanism of injury, treatment center type, injury grade, complications, procedures, transfusions, imaging studies, ICU and total lengths of stay, mortality and discharge information were abstracted. Comparisons were made among children (ages 0-12 years), adolescents (13-18 years), and adults (19 years and greater). Univariate analyses were performed using chi-squared tests and Fisher's exact tests when appropriate. Multivariate logistic regression analyses examined the influence of age group and injury severity on various outcomes.

**Results:** A total of 6605 patient were identified: 672 children, 1157 adolescents, and 4776 adults. Adolescents fell in between children and adults, with significant ( $p < 0.05$ ) differences in the majority of categories: mortality, incidence of VTE, VTE prophylaxis, total complications, length of stay (LOS), ICU admissions, discharge locations, splenic embolization, imaging, and operative rates (Table 1). Multivariate logistic regression analysis, controlling for injury severity, demonstrated significant differences across the age groups for these outcomes. Differences were also noted between adolescents treated at pediatric centers compared to those treated at adult centers, with rates of VTE prophylaxis, operations, splenic embolizations, CT scans, blood transfusions, and total lengths of stay all being significantly higher at the adult centers.

**Conclusion:** With regards to isolated splenic injury, although their characteristics are often more similar to children, adolescents are neither "big kids" nor "small adults," and demonstrate differences in their injury mechanisms, treatments and outcomes. Future management strategies for this population require careful consideration of this fact and subsequent research is needed in order to better characterize the unique place of the adolescent population in trauma.

	Children	Adolescents	Adults
Median Splenic Injury Grade (Interquartile Range)	3 (1-3)	3 (1-4)	3 (1-4)
VTE	0 (0%)	1 (0.08%)*†	59 (1.3%)
Received VTE Prophylaxis	5 (0.74%)	227 (19.6%)*†	2171 (45.5%)
PRBC Transfusion on Admission	16 (2.4%)	49 (4.2%)*†	757 (15.9%)
Embolization	1 (0.15%)	18 (1.6%)*†	180 (3.8%)
Operations	14 (2.1%)	90 (7.8%)*†	1281 (26.8%)
CT Scans	238 (35.4%)	497 (43.0%)*†	2478 (51.9%)
Hospital LOS Avg. (d)	3.63	4.53*†	7.1
ICU LOS Avg. (d)	2.52	3.09*†	4.32
Any ICU Admission	274 (40.8%)	603 (52.1%)*†	3127 (69.9%)
Discharged Home	659 (98.1%)	1099 (95%)*†	3696 (77.4%)
Mortality	0.30%	0.43%*	2.7%
Total Complications	57 (8.5%)	146 (12.6%)*†	1194 (25.0%)
MCC of Injury	Accidental Falls (34.2%)	Motor Vehicle Traffic Accidents (31.8%)	Motor Vehicle Traffic Accidents (47.5%)

\* Significant compared to adults ( $p < 0.05$ )

† Significant compared to children ( $p < 0.05$ )

## PEDIATRIC HELICOPTER TRANSPORT: FLYING LESS BUT ALSO LESS INJURED

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**Introduction:** Helicopter-transport (HT) is used for up to 16% of pediatric traumas. However, no clear guidelines for the use of HT in pediatric trauma exist. The survival advantage of HT for pediatric trauma compared to ground-ambulance (GA) when controlling for transport time is not known. We hypothesized the rate of HT has decreased nationally and risk of mortality for HT to be similar when adjusting for transport time, compared to GA.

**Methods:** The Pediatric Trauma Quality Improvement Program (2014-2016) was queried for patients aged  $\leq 16$ -years-old transported by HT or GA. A multivariable logistic regression was used.

**Results:** HT was used in 4,527 (17.7%) patients. The rate of HT from scene decreased from 21.2% in 2014 to 18.2% in 2016 ( $p < 0.001$ ) with a geometric mean annual decrease of 19.3%. The rate of HT for minor (ISS $<15$ ) (overall, 13.9%) and major (ISS $>15$ ) (overall, 36.8%) trauma also decreased during this time. After controlling for pre-hospital transport time and known predictors of mortality, HT was associated with decreased risk of mortality for only those with major injuries transferred from scene (OR 0.48, 0.26-0.88,  $p < 0.001$ ), compared to GA. Risk of mortality for HT vs. GA in minor trauma was similar (Table A).

**Conclusion:** The rate of HT in pediatric trauma has decreased. However, there is still room for improvement as 14% of those with minor trauma continue to be transported by HT. Given the similar risk of mortality in this group compared to GA, future research is needed to develop pediatric guidelines in the hopes of minimizing this high over triage rate.

Table A. Adjusted\* risk of mortality for pediatric trauma patients transported by helicopter vs. ground-ambulance stratified by trauma severity

	Transport from Scene			Interfacility Transfer			Scene + Interfacility Transfers		
	OR	CI	p-value	OR	CI	p-value	OR	CI	p-value
<b>All trauma</b>	0.47	0.26-0.85	0.01	1.61	0.68-3.79	0.28	0.79	0.50-1.24	0.30
<b>Minor</b>	0.07	0.01-5.51	0.23	5.23	0.25-9.78	0.96	0.74	0.11-4.98	0.76
<b>Major</b>	0.48	0.26-0.88	0.01	1.39	0.55-3.47	0.48	0.79	0.50-1.25	0.32

\* controlled for: age, gender, injury severity score, severe grades for abbreviated injury scale of the head, thorax and abdomen, hypotension on admission, respiratory rate on admission, heart rate on admission, motor component of Glasgow coma scale score, mechanism and total transport time including dispatch

## CHARACTERIZATION OF TRAUMA-INDUCED COAGULOPATHY IN PEDIATRIC PATIENTS WITH SEVERE ABUSIVE COMPARED TO ACCIDENTAL HEAD TRAUMA

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**Introduction:** Trauma-induced coagulopathy (TIC) is a well characterized phenomenon that has been shown to be associated with severe head trauma (HT). Pediatric HT, and particularly abusive head trauma (AHT), is a frequent cause of severe injury in children. Differences in patterns of TIC between abused and accidental HT patients may help explain the disparate levels of morbidity and mortality seen in these populations.

**Methods:** We queried our institution's Level 1 pediatric trauma center registry and selected patients who had undergone rapid thromboelastography (TEG) from 6/1/2015 to 2/1/2019 and sustained blunt accidental or abusive severe HT (head AIS $\geq$ 3). Variables of interest were collected: demographics, injury-related data (GCS, ISS, head AIS), admission TEG parameters and traditional tests of coagulopathy (PT, PTT, INR, platelets), and mortality. Abnormal patterns of coagulopathy were defined: abnormal clot strength (MA $\leq$ 55, K $\geq$ 2.5, and/or platelets $\leq$ 150), abnormal fibrinolysis (LY30 $\geq$ 3% or  $\leq$ 0.8%), and elevated INR (INR $\geq$ 1.3). Statistical analyses including Wilcoxon rank-sum,  $\chi^2$ , Fisher exact, and logistic regression were utilized.

**Results:** 181 children were included in our analysis, 35 with AHT and 146 with accidental HT. The overall HT group was severely injured (median ISS (interquartile range (IQR)) 22 (14-29), median head AIS 4 (3-5) with a mortality rate of 10.7%. The AHT group was significantly younger (median age 0.4yr (0.17-1.5) v. 7yr (3-13),  $p < 0.0001$ ), more severely injured (median ISS 26 (18-30) v. 19 (11-29),  $p = 0.015$ ), with a lower worst GCS (median GCS 3 (3-12) v. 11 (3-15),  $p = 0.025$ ), and a higher mortality rate (21.2% v. 8.28%,  $p = 0.03$ ). Compared to the accidental HT group, the AHT group more frequently had an elevated LY30 (37.5% v. 13.4%,  $p = 0.019$ ) and an elevated INR (42.9% v. 25.5%,  $p = 0.042$ ). On univariate analysis (Table 1), patterns associated with an increased odds of mortality include abnormal clot strength (low platelets, elevated K, and/or low MA) in the AHT group and an abnormal LY30 (elevated or low LY30) in the accidental HT group. Elevated INR was associated with increased odds of mortality in both groups (Table 1).

**Conclusion:** Victims of AHT have a different pattern of coagulopathy as compared to those with accidental HT. Furthermore, only abnormalities in platelet count and clot strength in AHT patients are associated with death, representing a difference in prognostic value for this abnormality between abused and accidental HT patients. Further investigation is required to explain the mechanism which drives these differences in coagulopathy and their relationship with the pathophysiology of HT in children.

	AHT (N=35)		Accidental HT (N=146)	
	Death (OR)	P value	Death (OR)	P value
Abnormal Clot Strength	22	0.010	3.59	NS
• low platelets	10	0.081	1.62	NS
• low MA	11	0.097	3.14	NS
• Elevated K	48	0.029	1.68	NS
Abnormal Fibrinolysis	2.66	NS	9.5	0.035
• Elevated LY30	0.8	NS	2.4	NS
• Low LY30	4.5	NS	2.82	NS
Elevated INR	38	0.001	102.7	<0.0001

Table 1: Univariate associations between coagulopathy patterns and death; NS = not significant.

## THE TRUE COST OF PEDIATRIC GUN SHOT WOUNDS

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**Introduction:** Gunshot wounds (GSW) are the second leading cause of trauma-related death among U.S. children 1-17 years old. Injury prevention has been shown to reduce blunt forms of injury. We sought to determine the magnitude, health impact and costs associated with pediatric GSWs, as a first step to developing an injury prevention strategy to reduce firearm related injuries and deaths among children in our state and region of the U.S.

**Methods:** Children 1-17 years old who sustained gunshot wounds between 2008-2018 were identified from the trauma registries at two pediatric trauma centers (ACS Level 2 and ACS Level 1). Both centers serve different patient populations, with the Level 2 serving an urban area and the Level 1 serving a seven-state region. Demographics, operative intervention, complications, follow-up, readmission rates, hospital charges, and costs of care at both centers were analyzed.

**Results:** Patients were predominately male (86%, 203/236) and the mean age was  $14 \pm 4.8$  years. One fifth (20%, 47/236) required RBC transfusion, with 30 patients (13%) resuscitated in a 1:1:1 fashion and 10 patients (4%) requiring massive transfusion protocol activation. Nearly half underwent a major operation (47%, 111/236), including 30 (12.7%) who had an exploratory laparotomy and 25 (10.5%) who had repair of a major vascular injury. Twelve had an ED thoracotomy, of which four survived. The average ICU length of stay (LOS) was  $2.3 \pm 5.5$  days and the average hospital LOS was  $4.2 \pm 7.3$  days. Median Injury Severity Score (ISS) was 10.6 (1-75) and the overall mortality rate was 8.9% (21/236). Helicopter transport was utilized for 13.1% (31/236) with an estimated cost of \$40,000 per patient trip, or \$1.2 million during the study period. Cost of surgical care was \$11 million. Those with Medicaid coverage (67%) had a longer average LOS (17.4 days) compared to those with private insurance (6.1 days). The 30-day readmission rate was 3.3% (8/236). The overall cost for patient care was > \$21 million or \$93,130 per patient, with an estimated loss of \$3 million for both institutions.

**Conclusion:** Firearm-related injuries are a significant cause of childhood death and disability in the U.S. Nearly half of the patients in our study required a major operation and 9% succumbed to their injuries. Many who survived are hampered by lifelong physical and/or psychological disabilities. These injuries impart significant costs to our communities and trauma centers. By bringing these costs to light we aim to educate our legislators and partner with our communities, to identify and fund injury prevention strategies that will reduce the economic and societal costs of pediatric firearm-related injuries.

## LAPAROSCOPY COMPARED TO LAPAROTOMY FOR THE MANAGEMENT OF PEDIATRIC BLUNT ABDOMINAL TRAUMA

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**Introduction:** In hemodynamically stable injured children with a concerning abdominal exam and non-diagnostic imaging, operative intervention is warranted to diagnose and manage potential intra-abdominal injuries. However, there is minimal evidence evaluating the risks and benefits of laparoscopy compared to laparotomy in this group of patients. The objective of this study was to evaluate post-operative outcomes in a large cohort of hemodynamically stable pediatric patients with blunt abdominal injury and without severe traumatic brain injury or severe multi-system trauma, who underwent either laparoscopy or laparotomy.

**Methods:** Using the 2015-2016 NTDB, all patients age <18 years with  $ISS \leq 25$ ,  $GCS \geq 13$ , and normal blood pressure who underwent an abdominal operation for blunt abdominal trauma were included in the study cohort. Patients were grouped into three treatment groups: laparotomy, laparoscopy only, and laparoscopy converted to an open operation. The outcomes of interest were hospital length of stay, ICU length of stay, ventilator days, number of abdominal procedures, in-hospital mortality, and a predetermined list of complications. Multinomial logistic regression with inverse probability weighting to account for confounding by indication (including age, mechanism of injury, Glasgow Coma Scale, heart rate, intubation status, injury severity score, hospital trauma level, hospital teaching status, and number of facility pediatric abdominal trauma operations performed per year) was used to determine the association between treatment group and the outcomes of interest.

**Results:** Of 720 patients, 506 underwent laparotomy, 132 laparoscopy only, and 82 laparoscopy converted to open. Median age of the cohort was 10 (IQR: 7-15) years and median ISS was 9 (IQR: 5-14). Mean hospital length of stay was 2.1 days shorter (95% CI: 0.9-3.2 days) and mean ICU length of stay was 1.0 day shorter (95% CI: 0.6-1.5 days) for the laparoscopy group compared to the laparotomy group. There was no difference in post-operative complications, except the laparoscopy group had a 1.9% lower mean probability of surgical site infection than the laparotomy group (95% CI: 0.1-3.0%). There was no difference in ventilator days, number of abdominal procedures, and in-hospital mortality between the laparoscopy and laparotomy group and there were no differences in any outcomes between the laparoscopy converted to open and the laparotomy group.

**Conclusion:** In this cohort of hemodynamically stable pediatric patients with blunt abdominal injury, laparoscopy was associated with shorter hospital and ICU length of stay and lower risk of surgical site infection. This is the first study to compare outcomes after laparoscopy and laparotomy in a cohort of pediatric patients with similar baseline injuries, demonstrating that laparoscopy may have improved outcomes over laparotomy.

**PEDIATRIC TRAUMA ARRIVAL TIMES AND THE SWING SHIFT**

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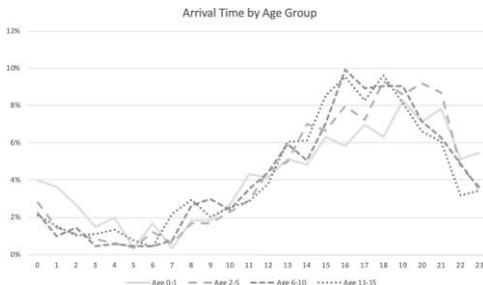
**Introduction:** Exposure to a high number of pediatric trauma cases is necessary to learn trauma management of the pediatric patient, gain comfort with a variety of injuries requiring emergency management, and gain exposure to uncommon patient care scenarios. Trauma center staff and trainees are often assigned to a day and night shift in many teaching hospitals. However, for adult trauma, the swing shift has been found to offer superior clinical exposure compared to a standard day or night shift for trainees. We characterized patterns in pediatric trauma arrival times according to the hour of the day, day of the week, and month, and studied whether or not the swing shift also maximizes opportunities to manage pediatric trauma.

**Methods:** We performed a retrospective review of the trauma registry at our urban, Level 2 pediatric trauma center. We identified all the pediatric trauma activations in the last 13 years (2006-2018). Hourly volumetric trends were modeled using a negative binomial regression. We included in this analysis models for 4 age groups: age 0-1, 2-5, 6-10, and 11-15. A retrospective shift log of the last 13 years was created, which included day (7:00 AM to 7:00 PM), night (7:00 PM to 7:00 AM), and swing (noon to midnight) shifts. The shifts were compared using the Wilcoxon match-pairs signed rank test. P values were multiplied by 3 for Bonferroni correction of multiple comparisons. To determine whether weekends yielded higher volume of pediatric trauma than weekdays, a Poisson regression model was used, and the  $\chi^2$  statistic calculated to determine goodness of fit. A Poisson regression model was also used to compare months of the year. Similar analyses were utilized to compare data of pediatric patients with Injury Severity Scores (ISS) >15, using a Wilcoxon test to compare shifts, and Poisson regression modeling to compare weekdays versus weekends, as well as months of the year.

	Total	Blunt	Penetrating	ISS >15	Fall < 10 ft	MVC
All patients (N)	3532	3322	210	693	1158	1116
Age (IQR)	7.2 (3-12)	7.1 (3-12)	8.5 (4-13)	6.8 (2-12)	5.0 (1-8)	7.9 (4-12)
Males (%)	2231 (63.2)	2075 (62.4)	156 (74.3)	439 (63.3)	704 (60.8)	800 (71.7)

**Results:** 3532 pediatric patients were identified for our study. Peak arrival time was between the hours of 3:00 PM and 9:00 PM. Patient age, ISS, and whether the mechanism was blunt or penetrating did not have a significant effect on patient arrival times. The swing shift had 1.98 times more activations than the night shift, and 1.33 more than the day shift (p <0.001). The swing shift was also superior to both the day (odds ratio: 1.26, p <0.001) and night shifts (odds ratio: 1.79, p <0.001) for patients with ISS >15. Weekend days had 1.28 times more trauma than the weekdays (p < 0.001), with Saturday the single day with the highest volume. Our Poisson regression model did not demonstrate that any particular months of the year had more trauma.

**Conclusion:** At institutions with training programs, it is helpful to be aware of the times with the highest trauma volume. Our study suggests that the hours between 3:00 PM and 9:00 PM represent a time of particularly high likelihood of pediatric trauma arrivals. These hours are included by the swing shift. Trauma activations for patients with ISS >15 also peak during these hours. The increased volume and higher acuity of patients during the swing shift can be utilized to provide important opportunities for trainees to develop competence in pediatric trauma. In addition, the hours between 3:00 PM and 9:00 PM on weekends may represent a time of particularly high likelihood of pediatric trauma arrivals, which may require extra staff and hospital resources.



**PLATELET TRANSFUSIONS ARE ASSOCIATED WITH IMPROVED MORTALITY IN PATIENTS WITH SEVERE TRAUMATIC BRAIN INJURY. A SECONDARY ANALYSIS OF THE PRAGMATIC, RANDOMIZED OPTIMAL PLATELET AND PLASMA RATIOS (PROPPR) TRIAL**

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**Introduction:**

Patients with severe traumatic brain injury (sTBI) develop an acquired coagulopathy that is associated with poor outcomes. Platelet transfusions have been suggested to decrease mortality in patients with sTBI who develop an acquired coagulopathy. The objective of this study was to examine the effect of platelet transfusions on mortality in patients with severe TBI.

**Methods:**

We analyzed the data from the PROPPR trial. In this trial subjects at 12 North American level 1 trauma centers were randomized into either a 1:1:1 or 1:1:2 (plasma:platelets:red blood cells) transfusion ratio intervention for massive transfusion. During the randomization the first cooler of blood products either did or did not contain platelets. We identified a subgroup of patients with sTBI (AIS Head  $\geq 3$ ) who received only the first cooler of blood products, which did not contain platelets. We then compared those who received platelets to those that did not. Variables were compared using univariate analysis, Cox regression and Kaplan-Meier method to estimate mortality. Our primary outcomes were 24-hour and 30-day mortality.

**Results:**

A total of 40 sTBI patients were included (Platelet transfusion n=22; No platelet transfusion n=18). There were no significant differences in demographics, admission physiology, ISS, Head AIS, or coagulation parameters between the groups. Patients who received platelet transfusions had a significantly lower mortality rate than those who did not receive platelet transfusions (27% vs. 61%; p=0.023). A Cox regression analysis for 30-day mortality demonstrated that both platelet transfusions (HR 0.23, 0.09-0.62 95% CI, p=0.004) and a GCS >3 (HR 0.10, 0.01-0.79 95% CI, p=0.029) were associated with improved survival. Kaplan-Meier curve analysis demonstrated a significant reduction in cumulative incidence of early and late death in patients who received platelets (Figure 1)

**Conclusion:**

In patients with severe TBI platelet transfusions appear to be associated with decreased early and late mortality.

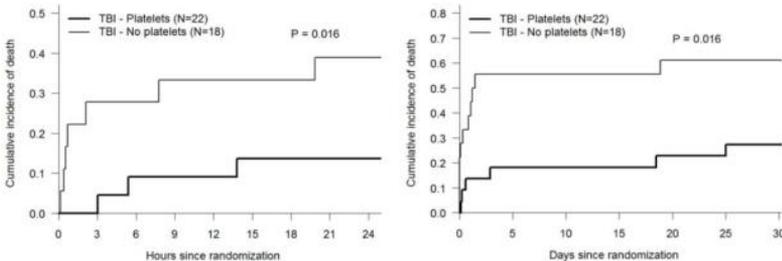


Figure 1. (Left) Cumulative incidence of death within first 24 hours after randomization. (Right) Cumulative incidence of death within 30 days of randomization.

## **EFFECT OF PLATELET TRANSFUSIONS ON MORTALITY AND NEUROSURGICAL INTERVENTION IN TRAUMATIC INTRACRANIAL HEMORRHAGE ON PRE-INJURY ANTIPLATELET THERAPY**

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**Introduction:** Traumatic intracranial hemorrhage (tICH) is a significant cause of mortality in trauma patients, with a worse prognosis in patients on pre-injury antiplatelet medication (APM). Currently several studies with poorly matched cohorts exist with no randomized control studies or practice management guidelines regarding the utility of platelet transfusions in these patients. We hypothesize that platelet transfusions will have no significant effect on mortality or need for neurosurgical intervention in patients with tICH on APM.

**Methods:** We analyzed all tICH patients on APM admitted to a Level 1 Trauma center from 1/1/14 to 12/31/18. A hospital-wide protocol change occurred on 9/1/17 to discontinue platelet transfusions in tICH on pre-injury APM. The cohorts were matched based on AIS head, ISS, Demographics, MOI, GCS, type of APM and coagulopathy. The primary outcome was mortality and secondary outcomes; rate of neurosurgical intervention, hospital length of stay, critical care days, and discharge destination. Statistical analyses include Chi-square, T-test statistics and a population that fulfilled the power analysis.

**Results:** 610 patients were included (449 platelets (P), 161 no platelets (NP)). Differences between P and NP groups were not significant based on age ( $p=0.055$ ), gender ( $p=0.59$ ), race ( $p=0.281$ ), ISS ( $p=0.161$ ), GCS ( $p=0.461$ ), and INR ( $p=0.406$ ). AIS head between P and NP was significant ( $p=0.013$ ), however AIS specific to the tICH was not ( $p=0.21$ ). APM type was not different between P and NP groups ( $p$ -values for ASA=0.8, ASA+Plavix=0.09, Plavix=0.13, Other=0.98). No differences were found between the P and NP groups for mortality ( $p=0.34$ , CI=95%), rate of neurosurgical intervention ( $p=0.072$ , CI=95%), length of stay ( $p=0.567$ , CI=95%), critical care days ( $p=0.54$ , CI=95%) and discharge destination ( $p=0.36$ , CI=95%). Subgroup analyses specific for type of tICH also revealed no difference in primary or secondary outcomes.

**Conclusion:** This is one of few studies investigating administration of platelets for antiplatelet reversal in patients with tICH with matched cohorts. Platelet transfusions do not significantly improve mortality, need for neurosurgical intervention, length of stay, or discharge destination in tICH patients on pre-injury APM. Further studies should focus on volume expansion and multi-center trials to help establish better trauma management guidelines.

## THE PREDICTIVE ABILITY OF THE GLASGOW COMA SCALE FOR SEVERE TRAUMATIC BRAIN INJURY DECLINES WITH AGE

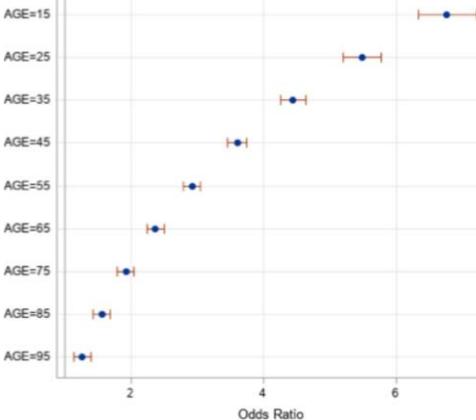
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**Introduction:** The Glasgow Coma Scale (GCS) measures the severity of neurologic deficit (coma and impaired consciousness). We first reported that older age  $\geq 65$  years affects the association between the GCS and the severity of the intracranial injury, as measured by the Abbreviated Injury Scale [AIS] score, in patients with traumatic brain injury (TBI). This confirmatory study sought to investigate further the effect of age on the association between GCS and AIS. We hypothesized that as we age, the presenting GCS becomes less associated with the severity of the TBI.

**Methods:** We included all patients in the National Trauma Data Bank from 2010-2015 with a TBI, defined by ICD9-CM diagnostic codes 850 through 854. We compared older ( $\geq 65$  years) vs. younger (18-64 years) adults with TBI; we also examined age by decile. Logistic regression was used to identify the association between age and GCS for severe TBI (AIS $\geq 3$ ), adjusting for sex, presenting systolic blood pressure  $< 90$ mmHg, mechanism, and isolated TBI.

**Results:** There were 106,581 patients with TBI (aged  $< 65$  years, 68%). There was a significant interaction ( $p < 0.001$ ) between age, GCS and head AIS when age was examined by decile and stratified into  $< 65$  and  $\geq 65$  years. The odds of presenting with GCS 3-8 was 2.1-fold greater for younger vs. older patients with a severe TBI (AIS $\geq 3$ ), after adjustment ( $p < 0.001$ ). These results were more striking when age was examined by decile (figure 1); GCS 3-8 had decreased odds of identifying severe TBI (AIS  $\geq 3$ ) with increasing age decile. The area under the ROC curve was greater in patients with isolated TBI (AUROC=0.78).

**Figure 1.** Odds (95% CI) of presenting with Glasgow Coma Scale 3-8 by age decile, for patients with severe TBI (AIS  $\geq 3$ )



**Conclusion:** This study confirms our previous findings in a large National sample and further demonstrates that the relationship between the presenting GCS and severity of the intracranial injury is modified by age incrementally; that is, this relationship is not limited to the elderly population, as the presenting GCS becomes less predictive of severe TBI with increasing age decile. These results may represent a blunted physiological response to injury with increasing age. Further study might examine whether GCS is a valid measurement in trauma activation.

**Primary blast-induced mild traumatic brain injury shows changes in MRI and immunohistology in a rat model of blast-induced behavioral abnormality**

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**Introduction:** Victims of blast-induced mild traumatic brain injury (mTBI) are increasing worldwide due to terrorism, and many suffer from after-effects of physical or mental impairment. Diagnosing primary blast-induced mTBI is difficult due to few findings on imaging. This study aimed to detect new findings for therapeutic intervention in a rat model of behavioral abnormality after blast-induced mTBI.

**Methods:** We used a bench-top blast wave generator with the blast wave exiting through a 20-mm I.D. nozzle aimed at the focused target. The blast wave was directed at the head of male SLC:Wistar rats weighing  $247\pm 3.9$  g under general anesthesia positioned prone 2.5 cm below the nozzle. Peak shock wave pressure at this point was  $646.2\pm 70.3$  kPa. Our previous study showed post-blast behavioral abnormality in this rat model in a forced swim test and Y-maze test. We assess this rat model with specialized magnetic resonance imaging (MRI) modalities (11.7-T scanner) and immunohistochemically at day 3, 2 weeks and 6 weeks after blast injury.

**Results:** The blast-induced mTBI model showed no macroscopic findings of brain hemorrhage or contusion. However, food intake decreased significantly in the blast group rats, and they lost weight compared to control rats (-18 vs. +10 g on day 3;  $P=0.001$ ) in the early post-injury phase. Behavioral analysis in the blast group showed increased immobility time in the forced swim test at 2 (165 vs. 125 s;  $P=0.006$ ) and 6 weeks (199 vs. 162 s;  $P=0.01$ ), and the percentage of spontaneous alternation in the Y-maze test was significantly smaller than that of the control group (82% vs. 60%;  $P=0.03$ ) at 2 weeks. Specialized MRI showed bilateral inflammation of the oriented layers of the hippocampus at 3 days and 2 weeks. Immunohistochemical analysis by Iba1 showed microglial accumulation in the same region, and detected activated microglia at 3 days and 2 weeks. Anti-neuronal nuclei (NeuN) antibody immunostaining showed a gradual decrease in NeuN-positive neurons over time in the pyramidal cell layer of the hippocampus.

**Conclusions:** Specialized MRI and immunohistochemical analysis enabled visualization of new abnormal findings of depressive-like behavior and short-term memory disturbance in a rat model of blast-induced behavioral abnormality.

## PROSPECTIVE EVALUATION OF DELIRIUM IN GERIATRIC PATIENTS UNDERGOING EMERGENCY GENERAL SURGERY

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### Introduction:

Delirium is a potentially preventable geriatric complication. The prevalence of delirium and its impact on outcomes following emergency general surgery (EGS) remains unexplored. The aims of our study were to assess the impact of frailty on delirium and the impact of delirium on outcomes in geriatric patients after emergency general surgery.

### Methods:

We performed a 1-year (2017) prospective cohort analysis of all geriatric (age  $\geq 65$ ) patients who underwent EGS at our institution. Frailty was calculated using the emergency general surgery specific frailty index (ESFI). Delirium was assessed using the confusion assessment method (CAM), based on which patients were classified dichotomously as delirious or non-delirious. We performed regression analysis controlling for demographics, admission vitals, ASA score, comorbidities, and the diagnosis and type of surgery.

### Results:

A total of 145 patients underwent emergency general surgery and were included. Mean age was  $71 \pm 7$  years, and 59% were male. Overall, the incidence of frailty was 38% and the incidence of postoperative delirium was 26%. Patients who developed postoperative delirium were more likely to be frail (40% vs. 14%,  $p=0.01$ ), on more than 3 medications (29% vs. 18%,  $p=0.03$ ), and were more likely to have 3 or more comorbidities (32% vs. 21%,  $p=0.03$ ). On regression analysis, frail status (OR: 4 [2.2-6.8],  $p<0.01$ ) and receiving  $\geq 3$  medications (OR: 2.1 [1.3-4.8],  $p<0.02$ ) were independent predictors of developing postoperative delirium. An episode of delirium was associated with longer hospital LOS (6 days vs. 3 days,  $p<0.01$ ), higher odds of ICU admission (OR: 2 [1.3-4.5],  $p<0.01$ ), longer ICU LOS (2 days vs. 1 day,  $p<0.03$ ) and higher odds of unplanned intubation (OR: 1.8 [1.2-3.4],  $p<0.02$ ).

### Conclusion:

One in every 4 geriatric patients developed postoperative delirium after an EGS procedure. Frailty and polypharmacy were associated with increased risk of delirium. Delirium appears to be associated with higher rates in-hospital adverse events. Frail patients should undergo postoperative monitoring and interventions to prevent delirium and improve outcomes.

**Osteopenia is associated with poor physical function one year post-injury in elderly trauma patients**

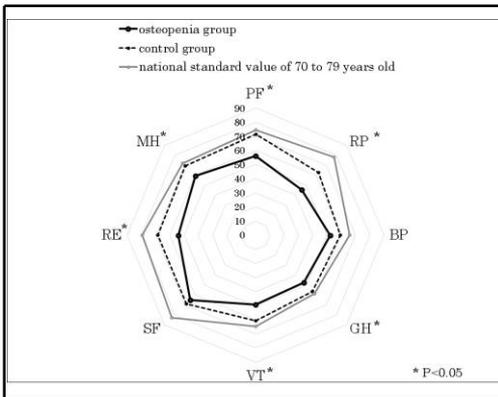
Nobuyuki Saito MD,MPH,Ph.D., Takanori Yagi MD, Hiroaki Iida MD, Takao Seo MD, Hisashi Matsumoto MBA,MD,Ph.D., Chiba Hokusoh Hospital, Nippon Medical School

**Introduction:**It is important to evaluate the physical fragility of elderly trauma patients admitted to the trauma surgical intensive care unit (TSICU). One of the physical fragilities can be evaluated based on absolute osteopenia that is measured using computed tomography (CT) on admission. We aimed to clarify the relationship between osteopenia and physical function (PF) one year post-injury in elderly patients.

**Methods:**This single-institutional prospective study included 116 injured patients (aged ≥65 years) who were admitted to the TSICU and survived until discharge between 2016 and 2017. The average radio-intensity in Hounsfield units per 1.5-2.0 cm<sup>2</sup> of L3 vertebral cancellous bone on admission CT (bone fragility index [BFI]) was used as a bone loss indicator. BFI <100 indicated osteopenia. Activities of daily living (ADLs) one year post-injury were evaluated using SF-36®, which contains eight items, including PF. We defined poor ADLs as <25 percentile of the national standard for the same age. We divided the patients into the osteopenia and control (without osteopenia) groups and compared these two groups.

**Results:**All patients experienced blunt injuries, including pedestrian injuries (25.0%) and falls (34.5%). Mean age was 73.4 years (men, 63.8%), median injury severity score (ISS) was 18 (interquartile range: 14–26), and median Charlson comorbidity score was 1 (0–1). The osteopenia group included 42 patients (36.2%); median BFI values were 77 (12.0–28.5) and 138 (118–154) in the osteopenia and control groups, respectively. Mean age (75.6 vs 72.2 years) and proportion of females (54.8% vs 25.7%) were higher in the osteopenia group than in the control group. Clinical frailty scales at the time of admission

were comparable between the two groups. No differences were observed in injured sites, treatment, and hospital stay duration between the two groups. The osteopenia group was more transferred to a rehabilitation facility and their ADLs after 1 year were also lower than the control group (Figure). Multivariate analysis, which was adjusted for age, severity, and gender, revealed that osteopenia was an independent factor for poor physical function one year post-injury (odds ratio, 2.59; 95% confidence interval, 1.08–6.19;



P=0.03).

**Conclusion:**In elderly trauma patients, osteopenia observed on CT at admission was associated with poor ADLs, especially physical function, one year post-surgery. Treatment for bone loss may be important for improving ADLs in elderly trauma patients.

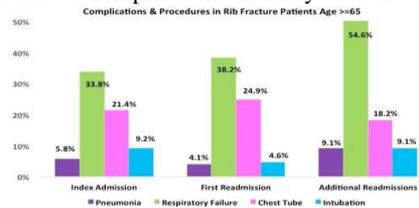
## NATIONAL READMISSION PATTERNS FOR TRAUMATIC RIB FRACTURES AMONG ELDERLY PATIENTS

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**Introduction:** Rib fractures in elderly trauma patients are associated with serious complications and increased mortality. Long-term healthcare utilization among geriatric rib fracture patients, particularly readmission rates, are not well understood. We hypothesized that older adults with rib fractures would experience poor outcomes including high rates of mortality and frequent readmissions. Furthermore, we hypothesized that readmission would be associated with conditions associated with their initial rib fractures.

**Methods:** We used the 2014 National Readmissions Database (NRD) from the Healthcare Cost and Utilization Project (HCUP). The NRD is a nationally representative database containing longitudinal inpatient data such that individuals can be followed for readmissions over the course of one year. We included all patients over the age of 65 with a primary diagnosis of trauma and identified patients with any diagnosis of rib fractures by ICD-9CM codes. Patients admitted between February-June 2014 were analyzed over a 6-month follow-up period. Demographic, injury and hospital characteristics, as well as readmission rates for rib fracture patients were evaluated. The primary outcome was readmission rate. Secondary outcomes included rates of complications that may be seen with rib fractures. Weighted data are presented to provide national estimates.

**Results:** Of 274,796 elderly trauma patients admitted during the 6-month study time period, 22,176 (8.1%) had a diagnosis of rib fractures. Rib fracture patients had a mean age of 78.9 years (SD: 0.1) and were more often female (n=11,816, 53.3%). Injuries in patients with rib fractures were severe. Compared to other trauma patients, those with rib fracture patients had higher rates of severe injury (ISS>15: 25.3% vs. 10.2%,  $p<0.001$ ) and were 3.6 times more likely to have multiple injuries (60.3% vs. 16.6%,  $p<0.001$ ). Flail chest was present in 10.8% (n=2,388) and 41.6% had an associated sternal fracture (n=9,221). Overall mortality rate at the index admission for rib fracture patients was 4.9% (vs. 3.1% in other trauma patients). For rib fracture patients who survived the index admission, the 6-month readmission rate was 6.3% and mortality at readmission remained high at 3.6%. While rib fractures are associated with other injuries, nearly half of readmitted patients (n=612, 44.5%) were patients with isolated thorax injuries. Readmissions for patients with rib fractures were complicated by high rates of rib-fracture-related complications and need for procedures. (see figure)



**Conclusion:** Rib fractures in older adults are increasingly common, can be lethal, and have long-term healthcare utilization needs. Mortality rates are high during index and readmissions, but these are likely underestimates given deaths that occur out-of-hospital. Furthermore, readmissions are associated with complications likely associated with the initial rib fracture injury, suggesting there is an opportunity to better address these injuries during the index admission.

## **DOES TIMING OF PALLIATIVE CARE INTERVENTIONS AFFECT HOSPITAL LENGTH OF STAY? A CROSS-SECTIONAL STUDY AT TWO LEVEL I TRAUMA CENTERS**

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**Introduction:** Providing early communication interventions to older adult trauma patients, including family meetings on goals of care (GOC) and palliative care consultations (PCC), has been suggested to improve quality of care and decrease hospital length of stay (HLOS). There are a paucity of studies examining palliative care in parallel to trauma care, and prior to November 2017, no American College of Surgeons (ACS) palliative care guidelines had been published. The purpose of this study was to compare timing of palliative care interventions, and their effect on HLOS, before and after implementation of the ACS Palliative Care Best Practice Guidelines.

**Methods:** This was a prospective, cross-sectional, pre-post study on trauma patients ( $\geq 55$  years) before (pre, 11/16-12/17) and after (post, 1/18-11/18) implementation of the ACS TQIP Palliative Care Best Practice Guidelines across two ACS-verified Level I Trauma Centers. Data on patient characteristics were collected from the trauma registry, physician rounds, family meetings, and medical records. The primary outcome was total HLOS (days). Secondary outcomes included time from admission to: PCC, GOC, and proportion of patients with PCCs within  $\leq 24$  hours of admission, and GOC meetings within  $\leq 72$  hours of admission. Data on patient characteristics and palliative care interventions were compared univariately between pre- and post-groups. Stepwise generalized mixed modeling (entry 0.1; exit 0.05) was used to adjust for differences in mean HLOS between groups by covariate. Statistical significance was defined as  $P \leq 0.005$ .

**Results:** There were 718 patients enrolled across both sites during the study (54%, pre; 46%, post). The majority were female (55%), with a mean (SD) age of 75.2 (11.1), had a median (IQR) injury severity score (ISS) of 9 (8-11), and a median HLOS of 4 (3-6) days. Compared to the pre-group, the post-group had a significantly shorter median HLOS (4 (3-6) vs. 4 (3-5),  $p=0.003$ ). In the post-period, significantly more patients had a PCC within 24 hours of admission (8% vs. 15%,  $p<0.001$ ) and a GOC meeting within 72 hours of admission (50% vs. 54%,  $p=0.005$ ), and median (IQR) hours from admission to GOC was significantly shorter (60.3 (39.2-76.2) vs. 44.6 (26.0-65.1),  $p=0.005$ ). After adjusting for ISS, hours from admission to GOC, and hours from admission to PCC, HLOS was not significantly different between the pre-post period.

**Conclusion:** Our study suggests that two components of the ACS Palliative Care Guidelines: earlier PCC and GOC meetings, as well as lower ISS, were driving the significant decreases in the mean HLOS, independently of the pre-post time period. Having early communication interventions for less critically-injured, older adult trauma patients may decrease HLOS. More studies are warranted to better understand the relationship of these interventions on HLOS.

**RIB FRACTURE PROTOCOL INCREASES VENTILATOR FREE DAYS AND DECREASES PNEUMONIA IN GERIATRIC TRAUMA PATIENTS**

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**Introduction:** Chest trauma associated with rib fractures contributes to significant morbidity and mortality in the geriatric population. Rib fracture protocols (RFPs) with clinical and radiographic scoring systems have been developed to guide the allocation of intervention strategies. However, few studies have analyzed the outcome and impact of these protocols. Our level I trauma center RFP recommends that patients with high risk scores be admitted to the ICU and receive epidural analgesia. In this study, we hypothesized that implementation of the RFP would improve outcomes in geriatric trauma patients.

**Methods:** All patients (age  $\geq 60$ ) admitted with one or more rib fractures to our level I trauma center with an Abbreviated Injury Score  $\leq 2$  for other regions from January 2010 to May 2018 were included in the study. Patient demographics, mechanism of injury, injury severity score, comorbidities, and clinical outcomes were analyzed. The study period was divided into two phases: Pre-RFP phase (2010 to June 2015), and Post-RFP phase (2016 to 2018). Our RFP were established based on age, radiographic evidence, and clinical evaluation. In our study, the rib fracture scores were assigned only using hard points of age and radiographic evidence as clinical evaluation could not be retrieved consistently. Data was analyzed by students t test and  $X^2$  test. Multivariate regression was used as required.

**Results:** A total of 416 patients who scored  $\geq 3$  in the RFP were included. 227 patients were in the Pre-RFP phase, and 189 patients were in the Post-RFP phase. There was no significant difference in demographics, injury severity and mechanism, or comorbidities between the two phases. Comparing the Post-RFP to Pre-RFP phase, there were significantly higher ICU admission rates (adjusted OR 5.84, CI 3.63-9.41,  $p < 0.001$ ), higher epidural usage (adjusted OR 1.69, CI 1.13-2.53,  $p = 0.01$ ), more ventilator-free days (1.91 vs. 1.32,  $p = 0.02$ ), and a lower rate of pneumonia (adjusted OR 0.17, CI 0.03-0.87,  $p = 0.03$ ) following RFP implementation. No significant differences were found in all-cause mortality (3.7% vs. 2.6%,  $p = 0.54$ ), hospital length of stay (6.96 vs. 6.5,  $p = 0.48$ ), ICU length of stay (2.76 vs. 1.88,  $p = 0.07$ ), and intubation rate (13.8% vs. 15.4%,  $p = 0.63$ ).

**Conclusion:** Implementation of the RFP increased the number of ventilator-free days and decreased the incidence of pneumonia in geriatric rib fracture patients. Correct utilization of the RFP appropriately triaged patients to ICU admission and epidural usage more frequently.

## THE WHOLE IS GREATER THAN THE SUM OF ITS PARTS: GCS VERSUS GCS-MOTOR FOR FIELD TRIAGE OF GERIATRIC TRAUMA PATIENTS

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**Background:** Accurate field triage is required to match injured patients to the appropriate level of care. Ideal triage criteria are simple and readily available to EMS providers. Prior work suggests the Glasgow Coma Scale (GCS) motor component (GCSm) is at least as accurate as the full GCS for field triage while being easier and more reliable to use. Older patients present with higher GCS values for a given level of head injury. Thus, it is unclear how substituting GCSm for GCS will perform in triage of geriatric patients. Our objective was to evaluate diagnostic performance of GCS versus GCSm in field triage for geriatric patients.

**Methods:** Patients  $\geq 16$  years in the NTDB 2007-15 transported from the scene were included.  $GCSm \leq 5$  was defined as positive field triage criterion. Presence of physiologic and anatomic triage criteria from the National Field Triage Guidelines (NFTG) were also identified. The primary outcome was trauma center need (TCN), defined as ISS  $> 15$ , ICU admission, ED disposition to the OR, or death in the ED. Diagnostic test characteristics including sensitivity, specificity, and area under the curve (AUC) were compared for NFTG including current criterion of  $GCS \leq 13$  or substituting  $GCSm \leq 5$  as would be applied in the field. Severe head injury ( $AIS \geq 3$ ) and craniotomy for patients with  $GCS \leq 13$  that have only a motor component deficit versus only a non-motor component deficit were compared. Logistic regression determined the association between TCN and  $GCS \leq 13$  or  $GCSm \leq 5$  while adjusting for other NFTG criteria. Analyses were performed for adult (age 16-65) and geriatric patients (age  $> 65$ ) separately.

**Results:** 4,480,185 patients were analyzed, including 1,258,190 geriatric patients. Geriatric patients had higher ISS (9 vs 6,  $p < 0.01$ ) and mortality (5.1% vs 3.5%,  $p < 0.01$ ). TABLE shows diagnostic performance in adult and geriatric patients for NFTG using  $GCS \leq 13$  vs  $GCSm \leq 5$  to identify TCN. In adults the AUC was similar for  $GCS \leq 13$  vs  $GCSm \leq 5$  ( $p = 0.06$ ). In geriatric patients the AUC was higher for  $GCS \leq 13$  vs  $GCSm \leq 5$  ( $p < 0.01$ ). Adults with motor-only deficits had higher severe head injury (28.4% vs 27.0%,  $p < 0.01$ ) and craniotomy (5.5% vs 4.4%,  $p < 0.01$ ) vs non-motor deficits. Conversely, geriatric patients with only non-motor deficits had higher severe head injury (40.3% vs. 36.7%,  $p < 0.01$ ) and craniotomy (5.8% vs 5.1%,  $p < 0.01$ ) vs motor-only deficits. For TCN in adults, the effect size of  $GCSm \leq 5$  (OR 5.96; 95%CI 5.90—6.02,  $p < 0.01$ ) was significantly greater than that of  $GCS \leq 13$  (OR 5.38; 95%CI 5.33—5.44,  $p < 0.01$ ). For TCN in geriatric patients, the effect size of  $GCS \leq 13$  (OR 4.82; 95%CI 4.74—4.90,  $p < 0.01$ ) was similar to that of  $GCSm \leq 5$  (4.82; 95%CI 4.72—4.91,  $p < 0.01$ ).

**Conclusion:** Substituting  $GCSm \leq 5$  for  $GCS \leq 13$  in the NFTG for adult patients has similar diagnostic performance and greater effect on TCN, while motor-only deficits were associated with greater rates of severe head injury and craniotomy. However, in geriatric patients,  $GCS \leq 13$  has better diagnostic performance and similar effect on TCN, while non-motor deficits were associated with greater rates of severe head injury and craniotomy. Thus, while use of GCSm for field triage may be appropriate for adult patients, the full GCS appears to be necessary for field triage in geriatric patients.

	Sensitivity (%)	Specificity (%)	Accuracy (%)	AUC
<b>Adult Patients</b>				
$GCS \leq 13$	54.7	75.2	68.0	0.644
$GCSm \leq 5$	53.4	76.2	68.0	0.643
<b>Geriatric Patients</b>				
$GCS \leq 13$	33.1	83.4	68.1	0.583
$GCSm \leq 5$	31.0	84.0	67.9	0.575

## **PREFERENCES AND PREDICTIONS REGARDING END-OF-LIFE AND PALLIATIVE CARE IN THE INTENSIVE CARE UNIT**

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**Introduction:** With an increasingly aging population the number of trauma patients 50 years and older admitted to the intensive care unit (ICU) continues to rise. In this population it is common to have to make decisions about end-of-life goals of care and the need for palliative care consultants. We sought to better elucidate the degree of uncertainty about end-of-life decisions and provider feelings about palliative care.

**Methods:** Our study is a prospective observational study of patients 50 years and older admitted to the ICU at our level one trauma center. ICU patients or their surrogates were approached, consented, and completed a survey which included questions with regards to prior discussions about end-of-life care and whether the patient would want to live ventilator-dependent. Additionally the nurse, resident, and attending were surveyed with their expectation for patient outcome and whether palliative care teams or comfort care order sets should be added. Patients were followed through to determine eventual outcomes. Data were compared using chi-square analysis and fisher's exact test.

**Results:** One hundred patients had data available for analysis. Surveys were completed by the patient for 39 while a surrogate completed the survey for the other 61 patients. When the patient answered 13% would want a ventilator long-term, 82% would not want a ventilator long-term and 5% were unsure; if the surrogate answered 5% thought the patient would want the ventilator long-term, 74% thought the patient would not want the ventilator long-term, and 21% were unsure. Sixty-four of those being surveyed had had a prior discussion while 36 had not. When a prior discussion had been had 5% would want a ventilator long-term, 86% would not, and 9% were unsure, this differed from when there was no prior discussion when 14% would want a ventilator long-term, 61% would not, and 25% were unsure.

Nurse, resident and attending predictions about hospital survival were very similar with all groups predicting survival in 82%. There were differences due to some being unsure such that nurses were unsure about 7%, residents were unsure about 5% and attendings were unsure about 9%. The differences between predictions were not statistically significant. Nurses, residents, and attendings had similar ideas about the appropriateness of comfort care with 18%, 17%, and 16% saying yes respectively. There was more variation in ideas about the appropriateness of a palliative care consult with nurses saying yes 27% of the time while residents and attendings only said yes 18% and 17.5% of the time.

**Conclusions:** One of the greatest difficulties in making end-of-life decisions lies in the uncertainty about what the patient would want. The significantly higher rates in being unsure for both surrogate decision makers or in cases where no prior discussion had been had highlights the importance of having more conversations about end-of-life and documentation of advance directives prior to traumatic events. The difference in nurse and physician ideas about the appropriateness of a palliative care consult was striking. It is possibly due to more interaction between nurses and the patients and families showing a greater need for further discussion and palliation than the physicians appreciate or to a bias by physicians against involving another service. Teasing out reasons for this difference is an area for further study.

## GERIATRIC TRAUMA MORTALITY – DOES TRAUMA CENTER LEVEL MATTER?

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**Introduction:** The geriatric population has unique challenges that require a specialized approach. It is a demographic reality that as the population ages it tends to situate itself in mostly rural and suburban environs. Given their mostly rural/suburban location Level II trauma centers (TCs), may offer greater exposure to and experience in managing geriatric patients. We hypothesized that geriatric patients would have decreased mortality at Level II TCs compared to their Level I counterparts.

**Methods:** The Pennsylvania Trauma Outcome Study database was retrospectively queried from 2003-2017 for geriatric (age  $\geq 65$ ) trauma patients admitted to Level I and II accredited TCs in Pennsylvania. Patient demographics, injury severity and clinical outcomes were compared to assess differences in geriatric care between Levels I vs. II TCs. A multivariate logistic regression model assessed the adjusted impact of care at Level I vs. II trauma center on mortality.

**Results:** 167,733 patients met inclusion criteria [Level I: 113,870 (67.9%); Level II: 53,863 (32.1%)]. The proportion of geriatric trauma patients across all Level I (n=18) & Level II (n=15) TCs was determined to be 29.1% and 36.3% (p<0.001), respectively. In adjusted analysis, care at Level II TC was associated with significantly improved mortality (AOR 0.773, 95% CI: 0.615-0.972, p = 0.027) (Table 1).

**Conclusion:** The higher proportion of geriatric patients at Level II TCs may contribute to the improved mortality observed at Level II vs. Level I TCs. While the underlying reason is likely multifactorial, availability of specialized geriatric care and consistent exposure to geriatric patients at Level II TCs may contribute to improved care. Future consideration for location of centers of excellence in geriatric trauma should include Level II trauma centers.

Variable	AOR (95% CI)	Mortality p
Level II vs. I	0.773 [0.615-0.972]	<0.027
Age	Reference	---
65-74	Reference	---
75-84	1.77 [1.675-1.869]	<0.001
85-94	2.21 [2.081-2.338]	<0.001
95 and above	3.22 [2.888-3.597]	<0.001
Male gender	1.600 [1.533-1.669]	<0.001
ISS	Reference	---
Mild: 0-9	Reference	---
Moderate: 10-16	2.29 [2.173-2.503]	<0.001
Severe: 17-25	6.72 [6.540-7.455]	<0.001
Profound: 26-75	24.64 [24.158-27.741]	<0.001
Admission SBP	0.99 [0.985-0.986]	<0.001
Hospital LOS	0.96 [0.952-0.959]	<0.001
		AUROC: 0.8097
ISS = injury severity score; SBP = systolic blood pressure; LOS = length of stay		

## THE IMPACT OF INTRACRANIAL PRESSURE MONITORING ON OUTCOMES IN GERIATRIC PATIENTS WITH TBI

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**Introduction:** Traumatic brain injury (TBI) remains a significant cause of morbidity and mortality in the geriatric population. Intracranial pressure (ICP) monitoring has been considered the standard of care following severe TBI. Although many studies have assessed ICP monitor usage in adults, few have examined the impact of ICP monitoring in the elderly TBI patient. The aims of this study were to determine the association between ICP monitoring and outcomes in the geriatric TBI patient population and to examine the effect of age on outcomes among patients with an ICP monitor.

**Methods:** We conducted a prospective multi-center study of geriatric patients with TBI across 43 trauma centers. Inclusion criteria were age  $\geq 40$  and computed tomography (CT)-verified TBI. Patients with injury to any other body region with an Abbreviated Injury Scale (AIS) score  $>2$  or presentation  $>24$  hours after injury were excluded. Information on demographic, injury, hospital course, and outcomes was collected. Age was categorized based on distribution. The primary outcomes were in-hospital mortality, length of hospital stay (LOS) and ICU LOS and functional outcome at discharge. We compared distributions of the outcomes across age categories overall and among individuals with ICP monitoring using Chi-square Goodness of fit and the Kruskal-Wallis test. Regression modeling (linear for continuous outcomes and logistic for binary outcomes) was used to estimate the effect of ICP-monitoring on outcomes in the entire sample, adjusting for age and potential confounders.

**Results:** Of 3081 patients, 135 (4%) had an ICP monitor placed. With increasing age patients were less likely to undergo ICP monitor placement ( $p < 0.001$ ). Among those receiving ICP monitors, 70% were male, 69% had a Glasgow Coma Scale (GCS) score  $< 9$ , and 96% had a head AIS  $> 2$ . Older patients with an ICP monitor were more likely to receive palliative interventions ( $p = 0.02$ ). (Table 1) Controlling for age, AIS-head, and GCS categories, and compared to patients who did not receive ICP monitoring, those with ICP monitors had an increased mean LOS (8.7 days, 95% confidence interval (CI) 7.4-10.1) and increased mean ICU LOS (5.8 days, 95% CI 4.7-6.9), decreased odds of good functional evaluation at discharge (odds ratio (OR) 0.49, 95% CI 0.27-0.89) and increased odds of mortality, but this was not statistically significant (OR 1.3, 95% CI 0.82-2.1,  $p = 0.3$ ).

**Outcomes in Geriatric Patients with ICP Monitors (N=135)**

Age	49-59 (n=69)	60-81 (n=55)	>81 (n=11)	p-value
Hospital LOS	19.1±14.2	15.9±12	11.6±11.1	0.12
ICU LOS	13.1±9.9	11.7±7.4	7.9±5.1	0.26
Palliative intervention (palliative care consults, discontinuation of life sustaining measures and hospice care)	29%	42%	73%	0.02
Mortality	36%	45%	55%	0.38
Outpatient follow-up (completely disabled)	10%	22%	27%	0.16

**Conclusion:** Although ICP monitoring is standard of care in adult patients with severe TBI, there are no available recommendations based on age. This study demonstrated that ICP monitoring is not frequently utilized in the 'very old' geriatric trauma patient, outcomes may be worse among these patients who undergo ICP pressure monitoring, and among those who survive, disability is worse. Based on these data, the use of ICP monitoring should be reconsidered in geriatric patients with TBI.

## A TALE OF TWO STROKES: THE CHALLENGES OF DIAGNOSIS AND MANAGEMENT OF BCVI AND NON-BCVI STROKES AT A LEVEL 1 TRAUMA CENTER

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**Introduction:** While there has been much interest in the early diagnosis and treatment of blunt cerebrovascular injury (BCVI) to decrease stroke rates, there is a paucity of research addressing non-BCVI strokes. We have perceived an increase in non-BCVI strokes at our center. The purpose of this study is to evaluate the incidence, treatment, and etiology of strokes in our trauma population in order to identify preventive strategies.

**Methods:** This study was a retrospective review of all adult trauma patients admitted to a level 1 trauma hospital who suffered a stroke during trauma admission from 2010 to 2017. Data was collected from the prospectively maintained trauma and stroke databases. Chi-square was used to compare categorical variables, which are presented as N (%). Mann Whitney U test was used to compare continuous variables, which are presented as median (IQR).

**Results:** Of the 43,674 adult trauma patients admitted during the study period, 99 (0.2%) were diagnosed with a stroke during the index admission. Twenty-one (21%) strokes were due to BCVI, of which, 79% received appropriate anti-thrombotic therapy at a median of 7 hours from time of arrival. Seventy-eight (79%) strokes were due to non-BCVI etiologies. Patients with non-BCVI strokes were older, less severely injured, and had more medical comorbidities compared to patients with a BCVI stroke (Table). While BCVI stroke patients were more likely to suffer multiple traumatic injuries from MVC (76% vs 28%,  $p < 0.001$ ), non-BCVI strokes had more isolated extremity injuries from fall mechanism (55% vs 10%,  $p < 0.001$ ). Over the study period, the age and volume of trauma patients admitted increased. Additionally, the rate of stroke ( $p < 0.001$ ) and BCVI increased ( $p < 0.001$ ). However, the rate of BCVI strokes decreased while the rate of non-BCVI strokes increased.

	BCVI stroke Median, N (%) N = 21	Non-BCVI stroke Median, N (%) N = 78	P-value
Age	44 (27, 55)	71 (58, 82)	<0.001
ISS	26 (20, 34)	11 (8, 18)	< 0.001
GCS in ED	8 (3, 15)	14.5 (9, 15)	0.028
Any medical comorbidity	12 (57.1%)	66 (84.6%)	0.013
Atrial fibrillation	0 (0%)	14 (18.0%)	0.037
Stroke or TIA	0 (0%)	17 (21.8%)	0.020
Pre-hospital ASA or Plavix	1 (4.8%)	12 (15.4%)	0.29
Pre-hospital oral anticoagulant	0 (0%)	10 (12.8%)	0.11
Mortality	8 (38.1%)	17 (21.8%)	0.16

**Conclusion:** Strokes are rare in the trauma population but are increasing as the trauma population ages. While BCVI strokes are decreasing at our level 1 trauma center despite an increased BCVI incidence, the majority of strokes are non-BCVI strokes. Furthermore, the patient population experiencing BCVI strokes are distinctly different from that with non-BCVI strokes; the latter are older, have more medical comorbidities, and are hospitalized after low mechanism traumatic injury. Medical optimization of comorbid conditions during trauma hospitalization will become increasingly important for stroke prevention as the population ages.

## IS ANTICOAGULATION REVERSAL NECESSARY PRIOR TO SURGICAL TREATMENT OF GERIATRIC HIP FRACTURES?

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**Introduction:** Geriatric hip fracture surgery for patients on pre-injury anticoagulants may increase the risk for blood loss and subsequent blood transfusions. Anticoagulation reversal is thought to lower these risks, however, data on blood loss and transfusions for patients whose anticoagulant was reversed is limited. In addition, not all direct oral anticoagulants (DOACs) have approved reversal agents; these patients often “watch and wait” for natural elimination of the anticoagulant, delaying surgery. The study objective was to compare outcomes between 1) patients not on anticoagulants 2) patients whose pre-injury anticoagulants were reversed, and 3) patients whose pre-injury anticoagulants were not reversed.

**Methods:** This was a multicenter retrospective observational study at four level 1 trauma centers. Patients ( $\geq 65$  years old) who sustained an isolated fragility hip fracture requiring surgery (January 2014-January 2018) were included. The primary outcome was the total volume of blood loss during hospitalization. Secondary outcomes included hospital length of stay (HLOS) and total volume of blood transfusions for: fresh frozen plasma (FFP), packed red blood cells (pRBC), cryoprecipitate, and platelets. All blood volumes are reported as cm<sup>3</sup>. Statistical analyses included: Fisher’s exact, chi-squared, and Kruskal-Wallis tests; linear mixed-effect (by facility), and logistic regression. Bonferroni adjustment for multiple testing was used for all between group comparisons;  $\alpha=0.025$ .

**Results:** Of the 381 patients included in the study, 144 (39%) were not on anticoagulants, 147 (40%) underwent anticoagulant reversal, and 75 (20%) were not reversed. The median (IQR) age was 83 (77-88) years old and 65% of patients were female. Pre-injury anticoagulants were DOACs (40%) and warfarin (60%). Anticoagulation reversal methods were vitamin K (32%), FFP (22%), factor VIIa (<1%), and “watch and wait” (53%). There were fewer reversed patients who walked without an assistive device (57%) than patients not on anticoagulants (75%), and not reversed (63%) patients,  $p<0.001$ . There were a higher proportion of reversed patients (22%) who had congestive heart failure (CHF) than patients not on anticoagulants (6%), and not reversed patients (9%),  $p<0.001$ . There were fewer reversed patients (8%) than patients not on anticoagulants (24%), and reversed patients (20%) who had a hemiarthroplasty  $p=0.01$ . The LS mean (SE) volume of blood loss was 141 (20) for not reversed patients, 152 (17) for patients not on anticoagulants, and 174 (16) for reversed patients, after adjusting for bipolar and unipolar hemiarthroplasty, however this was not significant. The LS mean (SE) volume of FFP transfusions was also not significantly different being 565 (130) for patients not reversed, 464 (81) for reversed patients, and 631 (217) for patients not on anticoagulants, after adjusting for enrolling facility. There was no difference in the HLOS, total volume of pRBC, cryoprecipitate, and platelet transfusions between groups.

**Conclusions:** Patients whose anticoagulant was not reversed prior to hip fracture surgery did not experience any significant increases in blood loss, blood transfusions, or HLOS. Our data suggests that patients taking pre-injury anticoagulants, with or without reversal, seem to have a similar risk of blood loss compared to patients not on anticoagulants.

**POSTER 52 WITHDRAWN**

## EVALUATING THE DECADE OF ACTION FOR ROAD SAFETY IN A RAPIDLY DEVELOPING COUNTRY: ARE WE USING THE RIGHT INDICATORS?

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**Introduction:** Qatar is a rapidly developing country with a population growth of 4% per annum driven by the influx of migrant workers needed for infrastructure development. Road traffic injuries [RTIs] are the leading cause of death; consequently, the country has participated in the Decade of Action for Road Safety [DoARS] coordinated by the United Nations Road Safety Collaboration, since 2011. Its goal is to reduce the number of road traffic deaths by 50% from 2011-2020. This study will evaluate the DoARS in Qatar, to date, linking publicly accessible national RTI data and globally accepted indicators.

**Methods:** Data, on road traffic deaths and injuries, from the Traffic Department, Ministry of Interior, the National Traffic Safety Committee and the Hamad Medical Corporation National Trauma Registry for the years 2011-16 were collected and analyzed. The absolute number of RTI deaths, the main DoARS indicator, was analyzed and compared with other, population-based, indicators.

**Results:** For the over-all DoARS indicator, the number of RTI deaths, Qatar has only improved by 13.2%; but death rates have dropped by 42.9%. There have been more RTIs, by 14.3%, but a 25.1% drop in their incidence rate. A reduction in the number and rate of pre-hospital deaths were the highest among all indicators analyzed. And the number of in-hospital deaths increased during the study period [see Table 1].

**Conclusion:** Qatar has made dramatic improvements in road safety since 2011, most notably in pre-hospital mortality. In similar settings, with rapidly transforming populations.

Table 1: Road Traffic Injury Indicators, 2011 & 2016, Qatar.  
Traffic Department, Ministry of Interior and Hamad Medical Corporation National Trauma Registry

	2011	2016	Absolute Change	Percent Change
RTI Deaths	205	178	-27 deaths	-13.2%
RTI Death Rate	12.6	7.2	-5.4 per 100,000	-42.9%
RTIs	791	904	+113 RTIs	+14.3%
RTI Rate	48.7	36.5	+12.2 per 100,000	-25.1%
Pre-Hospital RTI Deaths	167	134	-33 deaths	-19.8%
Pre-Hospital RTI Death Rate	10.3	5.4	-4.9 per 100,000	-47.6%
In-Hospital RTI Deaths	34	37	+3 deaths	+1.1%
In-Hospital RTI Deaths	2.1	1.5	-0.6 per 100,000	-28.6%

## INCREASING SMARTPHONE AND SOCIAL MEDIA PENETRATION STRONGLY CORRELATED WITH MASS SHOOTING INCIDENTS AND DEATHS IN THE UNITED STATES

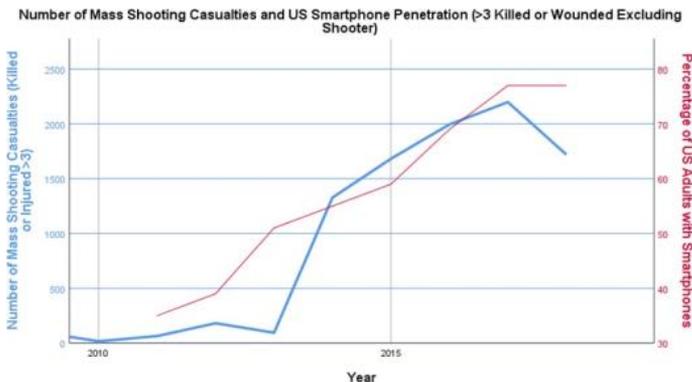
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**Introduction:** Mass shootings in the United States have risen significantly. The cause for this recent increase in violence is multifactorial and complex. Newly recognized risk factors for the development of mass shooters are increasing social isolation and media contagion. Omnipresent smartphones in society may increase media consumption while decreasing human social interaction. As such, we hypothesize that increasing smartphone penetration and social media in the United States may correlate with the rise in mass shooting events.

**Methods:** Data on US firearm commerce and homicides were obtained from federal agencies. The incidence and casualties from mass shootings, defined as  $\geq 4$  non-shooter individuals killed or wounded, were obtained from referenced, open-sourced datasets. Social media penetration was determined from annual corporate investor reports. Smartphone penetration was identified using national survey data from consumer and technology assessment companies and research centers. Graphical assessment and Pearson correlations were performed to identify trends correlated with the increase in mass shooting events.

**Results:** Mass shooting events and casualties remained constant prior to a noted increase in 2014. Smartphone penetration and the mean number of monthly active users of social media in the US market appear to follow a similar increase during the same timeframe. In contrast, new firearm delivery to the US market, regardless of weapon type, has steadily increased since 1996, without a 2014 spike as seen in both mass shootings and social media. Total firearm homicides, while increasing, demonstrate less change in frequency and remain below their height seen in the early 1990s. Over the last decade, mass shooting events and casualties were strongly correlated with mean monthly active users of Twitter ( $\rho=0.97$ ;  $p<0.001$  and  $\rho=0.98$ ;  $p<0.001$ ), Facebook ( $\rho=0.97$ ;  $p<0.001$  and  $\rho=0.87$ ;  $p=0.001$ ), and smartphone penetration ( $\rho=0.73$ ;  $p=0.040$  and  $\rho=0.93$ ;  $p=0.001$ ). New firearm production was not correlated to mass shooting events or casualties ( $\rho=0.60$ ;  $p=0.088$  and  $\rho=0.53$ ;  $p=0.14$ ).

**Conclusion:** Smartphone and social media penetration timelines strongly correlate with mass shooting events. However, it remains to be determined if these technological influences are causative. Further research is needed to identify any causal relationships and /or the existence of media contagion on the incidence of mass shooting events.



## RATES OF SUICIDE WITH FIREARMS SIGNIFICANTLY ASSOCIATED WITH NEW HANDGUN DELIVERY TO THE UNITED STATES MARKET

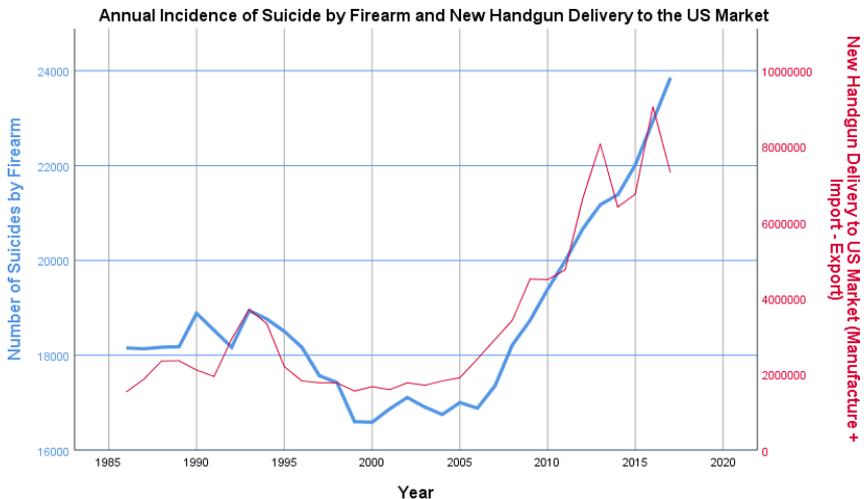
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**Introduction:** Firearm violence is increasingly recognized as national public health priority. While assault and homicide with firearms are the focus of most research and policy efforts, suicide is the predominant cause of firearm death. Suicidality is often multifactorial and complex. Although typically presumed secondary to mental health, large proportions of victims have no evidence of either mental illness or depression. Further efforts to limit firearm violence must include identification of the risk factors associated with suicide. One recognized risk factor is individual access to firearms. It remains unclear though, if there is any relationship between new firearm production and suicide rates. We hypothesize that rates of suicide by firearm are correlated to increased firearm delivery to the US market.

**Methods:** We performed a review of data from 1981-2018. Annual rates of suicide by firearm were obtained using the CDC WISQARS database. Firearm delivery to the US market was calculated as weapons manufactured plus imports minus exports. Data on firearm commerce was identified from annual ATF firearm commerce reports. Mental health data was obtained from the Substance Abuse and Mental Health Services Administration national survey results. Spearman's correlations and graphical analyses were performed over the available timeframes. Stepwise linear regression was used to identify significant risk factors for rates of firearm related suicide.

**Results:** Rates of suicide by firearm initially decreased in 1999 before steadily increasing starting in 2007. Rates of new handgun delivery to the market closely mirror the rate of suicide by firearm. From 2005-2017, handgun ( $\rho=0.93, p<0.001$ ) and total firearm ( $\rho=0.88, p<0.001$ ) delivery were strongly correlated with rates of suicide by firearm. The US unemployment rate ( $\rho=0.13, p=0.68$ ) and prevalence of major depression ( $\rho=0.49, p=0.10$ ) were not correlated with suicide rates while the proportion of adults with severe mental health disorders ( $\rho=0.70, p=0.04$ ) were weakly correlated. Only new handgun delivery to the US market was significantly associated with rates of suicide with firearms on multivariate linear regression ( $R=0.93, p<0.001$ ).

**Conclusion:** Rates of new handgun delivery to the US market are strongly correlated with rates of suicide in the United States. Further research and injury prevention strategies are needed to limit further suicide by firearm.



## ASSOCIATION OF INTERFACILITY HELICOPTER VERSUS GROUND AMBULANCE TRANSPORT AND IN-HOSPITAL MORTALITY AMONG TRAUMA PATIENTS

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**Introduction:** Relatively few studies have compared helicopter transport (HT) to ground transport (GT) for the *inter-facility* transport of trauma patients. Mixed results have been reported from these studies ranging from a slight increase in odds of survival for the severely injured to no evident benefit for HT patients. Previous studies did have notable limitations, the most significant being a lack of data from the transferring non-tertiary center (NTC) and no direct measure of distance between the NTC and tertiary trauma center (TTC). We sought to improve on existing studies by addressing these limitations. We hypothesized there was no adjusted difference in mortality between patients transported interfacility by HT or GT taking into account distance from TTC.

**Methods:** This was a retrospective cohort study of adult (18+ years old) trauma patients who initially presented to a NTC before subsequent transfer by HT or GT to a TTC. Data from 2005 to 2014 were obtained from an inclusive state-wide trauma registry. Records from the NTC and TTC were linked. Patients initially seen at a NTC closer than 21 miles and patients whose primary injury was burns were excluded. A total of 9,880 linked records were available for analyses. A propensity score using NTC demographic and clinical variables was developed to balance factors impacting selection to the HT and GT groups. We used propensity adjusted, multivariable Cox proportional hazards models to assess the association of HT on mortality at 72-hour and within the first 2 weeks of arrival at a TTC; these multivariable analyses were stratified by distance (miles) between NTC and TTC: 21-59, 60-90, and greater than 90.

**Results:** HT (N=3424) and GT (N=6456) patients were similar with respect to age and race however HT were slightly more often male. HT patients more often had penetrating injury and were more frequently injured in traffic-related incidents. Longer distance to the TTC was associated with increased length of stay at the NTC for HT patients, however this association was not observed for GT patients. Mean distance between NTC and TTC was greater for HT patients, 96.7 miles versus 69.9 miles for GT. Time from NTC arrival to TTC arrival was shorter for the HT group at each distance. A higher proportion of patients among the HT group had an ISS of 16 or higher (24.6% vs 10.9%), an initial SBP<90 mmHg (7.3% vs 2.8%), and GCS<10 (12.5% vs 3.7%) than the GT group. HT was associated with significantly decreased 72-hour mortality (HR 0.61, 95%CI 0.40-0.93) for patients transferred from a NTC <60 miles from the TTC. No association was seen for patients transferred more the 60 miles to the TTC. No significant association of HT and 2-week mortality was seen at any distance from the TTC.

**Conclusion:** Only for patients transferred from an NTC <60 miles from the receiving TTC was HT associated with a significantly decreased hazard of mortality in the first 72 hours. It appears the farther away the NTC the lower the threshold for using HT resulting in a large proportion of lesser injured patients being flown. A large proportion of HT patients, especially from the most distant NTCs, had minor injuries and normal vital signs at both the NTC and TTC suggesting the decision to use HT for these patients was resource-driven rather than clinical.

## BLEEDING TO DEATH IN A BIG CITY: AN ANALYSIS OF ALL TRAUMA DEATHS FROM HEMORRHAGE IN A METROPOLITAN AREA OVER ONE YEAR

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**Introduction:** Hemorrhage is the most common cause of potentially preventable (PP) trauma death, but no studies have focused on PP deaths from hemorrhage (PPH) across a large metropolitan area. We hypothesized that PPH deaths frequently occur too early for currently available resuscitation and hemorrhage control techniques.

**Methods:** All trauma-related deaths in a large US county were reviewed and patients were excluded if hemorrhage was not their primary cause of death. Deaths were categorized as PPH or non-preventable (NP). These categories were compared across mechanism of injury, death locations, anatomic locations of hemorrhage to determine significant differences using chi square test.

**Results:** 1848 deaths were reviewed and 258 (14%) were from uncontrolled hemorrhage. Half (129) of the 258 hemorrhagic deaths were PPH. There were 140 pre-hospital deaths, 47 (34%) of which were PPH. Of the 129 PPH, 47 (36%) occurred prehospital and an additional 25 (19%) died within 1 hour of arriving at an acute care setting. Isolated truncal bleeding was the cause of death in 102 (79%) of the PPH. Of those who died from PPH of the trunk, there was a nearly equal distribution among chest, chest/abdomen, abdomen, and all other truncal sources and combinations. 21 (27%) of the 77 PPH who died at their initial acute care setting were treated at non-level 1 trauma center.

**Conclusion:** The majority of PPH deaths in a large urban center occur in the pre-hospital setting or very early after hospitalization. Earlier, more effective prehospital resuscitation and truncal hemorrhage control strategies are required to improve outcomes in patients with potentially preventable deaths from hemorrhage.

<b>Preventability by Hemorrhage Location</b>			
	Total n (%)	Preventable/ Potentially Preventable n (%)	Non-Preventable n (%)
Total	258	129 (50.0)	129 (50.0)
Truncal	219	102 (46.6)	117 (53.4)
Chest	89	28 (31.5)	61 (68.5)
Abdominal	30	25 (83.3)	5 (16.7)
Pelvis	3	3 (100.0)	0 (0.0)
Combined Cavity	97	46 (47.4)	51 (52.6)
Truncal/Neck	5	3 (60.0)	2 (40.0)
Truncal/Junctional	7	5 (71.4)	2 (28.6)
Neck	2	0 (0.0)	2 (100.0)
Junctional	3	3 (100.0)	0 (0.0)
Truncal/Extremity	12	6 (50.0)	6 (50.0)
Extremity	9	9 (100.0)	0 (0.0)
Extremity/Junctional	1	1 (100.0)	0 (0.0)

## COMPARISON BETWEEN GEOGRAPHIC INFORMATION SYSTEMS (GIS) BASED ESTIMATES OF TRAUMA CENTER ACCESS AND TRAUMA REGISTRY DATA TO ASSESS EFFECTS OF CHANGES IN TRAUMA SYSTEM STRUCTURE

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**Introduction:** Geographic information systems (GIS) are often used to analyze trauma systems. GIS-based approaches can model access to a trauma center (TC), including estimates of transport time and population coverage, when accurate trauma registry and EMS data are not available or are not shared for various reasons. Our hypothesis is that estimates of trauma system performance calculated using a standard GIS method with public data will be comparable to those calculated using trauma registry data.

**Methods:** A standardized GIS-based method was used to estimate metrics of TC access in a regional trauma system in which the number of TC increased from 1 to 3 over a 3-year period. Registry data from a single TC in the system was evaluated for different time periods during this evolution. The number of admissions to the TC in different time periods was compared to changes in trauma patient distribution predicted by the GIS-based model, and the distribution of observed ground-based transportation times was compared to the predicted distribution.

**Results:** With the addition of 2 TC to the system, the volume of patients transported by ground to the index TC decreased by 30%, while the model predicted a 68% decrease in population having the shortest predicted transport time to the index TC. The model predicted the geographic trend seen in the registry data, but many patients were transported to the index TC even though it was not the closest center, so the impact was substantially less than predicted. The figures below illustrate the origin of admitted patients, and a heat map reflecting volume for each configuration. Observed transport times were uniformly shorter than predicted times, with a difference of about 20% for transport times < 20 minutes increasing to over 30% for transport times > 40 minutes. The observed probability distribution of transport times was also significantly narrower and skewed toward shorter times than the model prediction. There was a slight decrease in transport times to the index TC in the 3 center model compared to the 1 center model.

**Conclusion:** The GIS-based model qualitatively predicted changes in distribution of trauma patients, but registry data highlight that field triage decisions are more complex than model assumptions. Similarly, the model predicted transport times moderately well, but systematically overestimated, with the difference increasing with longer transports. This suggests that model assumptions, such as vehicle speed, based on normal traffic may not fully reflect EMS operations. There remains great need for metrics to guide policy based on widely available data. These observations provide guidance for the interpretation of GIS-based metrics in areas where registry and EMS data do not exist, and suggest ways that GIS-based models may be improved for trauma system use.



**POSTER #59-WITHDRAWN**

## **Predictors of Patient No-Shows to Post-Discharge Clinic Appointments Following Traumatic Injury**

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**Introduction:** Patients not presenting to clinic appointments increase healthcare costs with the average no-show rate across medical specialties around 23%. Little research has been done specifically for the trauma patient population. A study of orthopedic trauma patients found that 33.1% of patients did not attend their first clinic appointment after injury. The aim of this study was to evaluate risk factors for missing post-discharge, hospital follow-up appointments in a trauma population.

**Methods:** This was a retrospective chart review of patients who underwent exploratory laparotomy for traumatic injury by the trauma surgery service at an urban, Midwestern, level 1 trauma center and had a follow up scheduled in clinic after discharge. Clinically relevant demographic characteristics, patients' distance from hospital and the presence of staples, sutures, and drains requiring removal were collected. Home zip code was queried from US census data to identify the % of population living below the poverty line as a marker of socioeconomic status. Descriptive statistics of categorical variables were calculated as totals and percentages and compared with a  $\chi$ -squared test or Fischer's exact when appropriate. Aggregate rates were compared using one-way ANOVA. Logistic regression was preformed using R 3.5.2.

**Results:** The sample included 243 patients who were largely assaultive trauma survivors (69.5%), male (81.9%), African American (54.7%) with an mean age of  $30.0 \pm 17.8$ . Overall, 35.8% no-showed for their follow-up appointment. Risk factors on univariate analysis for no-show included African American (OR = 2.55 [1.39 – 4.68],  $p = 0.003$ ), assaultive/violent trauma (OR = 3.98[1.83 – 8.65],  $p < 0.0005$ ), non-private insurance, non-married (OR = 5.057[1.81-14.14],  $p = 0.002$ ) and lack of need for suture, staple or drain removal (OR = 2.21[1.24 - 3.95],  $p = 0.007$ ). On multivariate logistic regression modeling only assaultive/violent trauma (OR = 1.15,  $p = 0.0105$ ), non-private insurance (OR = 1.78,  $p = 0.005$ ), non-married status (OR = 1.22,  $p = 0.03$ ) remained significant.

**Conclusion:** Trauma patients are at high risk of no-show for follow-up appointments. Insurance type, marital status and mechanism of injury are associated with increased likelihood of no-show. Future work is needed evaluating interventions to improve follow-up and should focus on single assaultive trauma survivors with non-private insurance.

## PLACEMENT OF BLEEDING CONTROL KITS BASED ON LOCATION OF MASS CASUALTY EVENTS

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**Introduction:** Mass shootings and terrorist attacks in the United States pose a significant threat to public health. The Stop the Bleed campaign has worked to reduce the number of deaths from external hemorrhage. Although public bleeding control education has been well received, financial challenges have hampered the desired placement of bleeding control (Bcon) kits in all public spaces. Given a limited resource environment, the most effective placement of BCon kits in public spaces has yet to be determined. We sought to characterize the locations of mass shootings and terrorist incidents to better predict where public access BCon kits could potentially provide the greatest benefit and prevent loss of life from preventable hemorrhage.

**Methods:** This retrospective review examined mass casualty events of at least four shooting victims or terrorist events such as bombings or vehicular assault in the United States from January 2002 to December 2018. Shootings in public streets, residences and those without sufficient information were excluded. Information was sourced from public databases and records, including data from Mother Jones' Investigation, Global Terrorism Database, Gun Violence Archive, LA Times Deadliest US Mass Shootings, and Stanford Libraries Mass Shootings in America. Details regarding number of fatalities, casualties, weapon and location of event were elucidated. Location was further characterized based on ICD-10 location codes. Descriptive statistics were completed for analysis.

**Results:** 2411 events were reviewed and 730 events met inclusion criteria. The most frequent location was trade or service area at 69%, specifically private businesses at 34% and bar/nightclubs at 33%. The most frequent weapon was unspecified firearm, 65%, followed by handguns, 22%. Of those events for which specific location details were elucidated, 51% of casualties occurred inside, 44% outside, and 3% at entrance areas. 88% of incidents occurred between 2014-2018 which is likely attributable to increased tracking from the Gun Violence Archive.

ICD-10 Location Codes	2002-2018 730(100%)	Inside	Outside	Entrance	Unknown
<b>Trade and service area (Y92.5)</b>	<b>505 (69%)</b>	<b>217 (43%)</b>	<b>258 (51%)</b>	<b>16 (3%)</b>	<b>14 (3%)</b>
Private commercial establishments	250	107	127	11	5
Theater	6	2	3	0	1
Bar/nightclub	238	101	125	3	9
Transportation service areas	17	9	6	2	0
Airport	7	3*	2	2**	0
<b>School, other institution and public administrative area (Y92.2)</b>	<b>118 (16%)</b>	<b>66 (56%)</b>	<b>47 (40%)</b>	<b>5 (4%)</b>	<b>0 (0%)</b>
School, private/public/state	41	22	17	2	0
Religious institution	24	13	10	1	0
Hospital	11	7	4	0	0
Public administrative building	34	17	15	2	0
Protest/Demonstration	8	7	1	0	0
<b>Recreation area, park (Y92.8)</b>	<b>61 (8%)</b>	<b>58 (95%)</b>	<b>3 (5%)</b>	<b>0 (0%)</b>	<b>0 (0%)</b>
<b>Mass gathering event (Y92.3)</b>	<b>42 (6%)</b>	<b>27 (64%)</b>	<b>13 (31%)</b>	<b>2 (5%)</b>	<b>0 (0%)</b>
Concert	9	8	1	0	0
<b>Unspecified or Unknown (Y92.9)</b>	<b>4 (1%)</b>	<b>4 (100%)</b>	<b>0 (0%)</b>	<b>0 (0%)</b>	<b>0 (0%)</b>

\*ticket counter, baggage claim; \*\*in front of security, terminal entrance

**Conclusion:** The two-pronged Stop the Bleed approach of education and equipment availability to help reduce death due to preventable hemorrhage has seen challenges as it relates to placement of Bcon kits in public spaces. This study demonstrates that for those with limited funding, BCon kits would be most advantageous if placed at private businesses near points of egress. This study is limited by the availability and accuracy of previously collected data and news reports, and the public availability of data regarding events of this nature. Studies examining those injured on public streets and in private residences are needed.

## INSTITUTION OF VISION ZERO IN A MAJOR URBAN CITY: DOES IT REALLY WORK?

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**Background:** In 2013 in New York City (NYC), there were nearly 300 traffic fatalities, of which 60% resulted in a pedestrian death. In January 2014, the NYC government implemented the Vision Zero (VZ) Strategy, a multi-pronged approach to end all traffic fatalities, including increased patrol and enforcement, criminal charges for traffic violations, decreased city wide speed limits and improvements in traffic technology. The goal of this study was to evaluate the impact these strategies had on traffic mortality and injury.

**Methods:** Data from the City of New York, New York Police Department (NYPD) from 2013-2015 were analyzed. The study population consisted of all motor vehicle collisions (MVC) in all five boroughs of NYC. Populations were evaluated in two groups; those before the inauguration of the Vision Zero laws and policies in January 2014 and those after. Rates of MVCs involving non-fatal and fatal injuries to cyclists and pedestrians as well as overall mortality were compared.

**Results:** There were 627,449 MVCs in NYC during the study period, involving 157,700 injured people. Of the MVCs with documented causes, 0.11% were attributed to an "unsafe speed". 55,123 people were injured in the year pre-VZ (2013), 51,219 in 2014

	Pre-VZ (2013)	Post-VZ (2014-2015)	
Total MVC (n)	203,727	423,722	
Collisions associated with: (%)			
- Injured persons	20	18	p<0.00001
- Injured pedestrians	5.6	4.8	p<0.00001
- Injured cyclists	1.99	1.94	p<0.222
- Any fatality	0.14	0.12	p<0.01
- Pedestrian fatality	0.09	0.06	p<0.001
- Cyclist fatality	0.005	0.008	p<0.215

and 51,358 in 2015 (post-VZ). Of the collisions where there was a fatality, the rate declined from 0.14% to 0.12% (p<0.01). Collisions involving killed or injured pedestrians represented the majority, these rates decreased from pre to post-VZ (0.09%, 0.06% fatalities; 5.6%, 4.8% injured). Collisions involving killed or injured cyclists did not significantly change from pre to

post-VZ (1.99%, 1.94% injured; 0.005%, 0.008% fatalities).

**Conclusion:** The implementation of a multipronged government program which includes criminal charges for traffic violators, decreases in city wide speed limits, increased enforcements and patrol, as well as changes to traffic technology were associated with an overall decreased MVC related mortality and injury rate in a large urban city. This benefit was isolated to collisions involving pedestrian mortalities and injuries, as the rates were associated with a significant decrease after institution of VZ. This advantage did not translate to cyclists as the changes seen were not significant. Further research is needed to better understand how these changes impact the different types of injury and mortality associated with MVCs.

**Saving Lives in Low- and Middle-Income Countries: Repairing the Trauma Registry**

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**Introduction:** Trauma systems are effective in lowering injury-related death and disability in high income countries, through the evolution of costly and complicated care structures. Existing data is insufficient and irrelevant to limited resource settings, where over ninety percent of the world's injured are managed under very different circumstances. Registries are critical to measure the efficacy of interventions to improve injury related deaths. However, practical implementation of these registries in low- and middle-income countries (LMICs) is complicated by resource limitations. This study aims to identify the barriers to data collection, as well as solutions to overcome those challenges.

**Methods:** In October of 2015, the Panamerican Trauma Society Registry was implemented at six hospitals, 5 public and 1 private, in Santa Cruz de la Sierra, the capital city of Santa Cruz, Bolivia (population of 1.6 million). Three years after implementation, focus groups of attending and resident physicians were conducted at each hospital to evaluate the logistics of form completion, online data entry, and data download.

**Results:** Twenty-two individuals participated in the study. Barriers to the trauma registry data collection process included 1. Doubled workload: registry sheet is separate from medical record, 2. Short-staffing of nurses and physicians in the Emergency Department (ED), 3. Insufficient staff to upload completed forms, 4. Lack of recent trainings on data collection, entry, and upload, and 5. Lack of provider motivation to complete forms. Specific barriers to provider motivation involved 1. Lack of financial reimbursement, 2. Paucity of feedback received on the input data, and 3. Little to no change on resource allocation or distribution. Based on the feedback received and in collaboration with the local Ministry of Health (MoH), the following systemic improvements were proposed and implemented: 1. Incorporation of trauma registry items into existing medical record forms to create a standardized emergency medical record form, 2. Development of a new registry utilization training course and manual, 3. Written instructive and mandate from the government requiring the use of the new form at all second- and third-level hospitals, 4. Written and approved legislation to create a branch of government dedicated to the trauma registry and the emerging trauma system, and 5. Institution of quarterly hospital and MoH presentations on the data analyzed. (See Table 1)

**Conclusion:** Resource restrictions in LMIC's limit the effective implementation of trauma registries which are critical to understanding patient outcomes. Collaboration with governmental leadership can lead to systematic changes that will facilitate improved data collection. Moreover, coordination with all stakeholders involved leads to sustainable improvements. Future work will analyze the impact of the changes implemented in this program.

**Table 1. Focus Group Feedback**

<b>Barriers to Implementation</b>	<b>Barriers to Provider Motivation</b>	<b>System Improvements</b>
Lack of hierarchical mandate	No financial reimbursement	Standardized Emergency Medical Record form
Double the workload; separate forms	Lack of feedback on collected data	Government mandate for form utilization
Lack of ongoing registry utilization training and resident turnover	Unchanged resource allocation	New registry utilization course development
Short staffing in the ED		Formation of MoH branch dedicated to the trauma registry
Lack of registrars to upload information		Quarterly feedback presentations

## FACTORS ASSOCIATED WITH HOSPITAL DISCHARGE DELAYS IN PATIENTS WITH TRAUMATIC BRAIN INJURY

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**Introduction:** Hospital length of stay (HLOS) is affected by clinical and non-clinical factors. Patients with traumatic brain injury (TBI) may experience longer HLOS because of injury severity; additional discharge delays can lead to worse outcomes. We investigated clinical and non-clinical differences in TBI patients with and without a discharge delay. **Methods:** A multicenter retrospective study was conducted on patients age  $\geq 18$  with TBI and Injury Severity Score (ISS)  $\geq 9$  admitted to one of two level 1 trauma centers from 1/2015 to 3/2018. Discharge delay was discharge occurring  $\geq 24$  hours after case management notes indicated a patient was ready for discharge. Adjusted logistic regression analyses were used to explore the associations between discharge delay and patient demographics, Glasgow Coma Scale (GCS) score, ISS, time between admission and delay start (in delayed patients) or discharge (in non-delayed patients), undergoing a neurosurgical intervention prior to delay start or discharge, primary insurance type, secondary insurance utilized (yes/no), discharge destination, and comorbidities (substance abuse, bleeding disorder, cancer, cardiovascular disease, cirrhosis, respiratory disease, stroke, dementia, diabetes, kidney disorder, psychiatric disorder, obesity, current smoking). The two-way interactions between GCS/ISS and discharge destination were also considered for inclusion. Stepwise selection was used for final model selection, with entry and exit criteria of  $\alpha=0.05$ . SAS 9.4 was used for all analyses. **Results:** Of 1,065 patients, 115 (10.8%) had a discharge delay. Among delayed patients, the median (IQR) delay was 86 (51-161) hours. In the final regression model, lower GCS score, cirrhosis, psychiatric disorder, discharge destination, and primary insurance were significantly associated with discharge delay. Patients discharged to a psychiatric facility or intermediate care facility and those with Medicaid or commercial/private insurance had increased odds of delay. **Conclusion:** Discharge delays occur in a portion of patients with TBI and are due to clinical and non-clinical factors. Although approximately one-tenth of patients experienced a delay in the current study, this represented  $\sim 247$  days of delay per year. The two covariates that most influenced delay in adjusted models were presence of a psychiatric disorder and discharge destination. Non-clinical delays, especially those associated with discharge destination, should be targeted to reduce lengthened HLOS among TBI patients.

Factors independently associated with experiencing discharge delay*	
Total N=1,065	OR (95% CI)**
<i>Clinical Factors</i>	
GCS	0.93 (0.88-0.98)
Cirrhosis	5.95 (1.11-31.78)
Psychiatric disorder	4.23 (2.11-8.49)
<i>Non-Clinical Factors</i>	
Discharge destination	
Home	Ref
Hospice	0.88 (0.17-4.46)
ICF	16.20 (6.91-38.00)
LTC	6.60 (5.51-17.35)
Psych facility	49.02 (4.14-581.07)
SNF	12.40 (5.74-26.80)
Rehab	7.01 (3.56-13.80)
Primary insurance	
Commercial/private	Ref
Medicaid	1.12 (0.51-2.47)
Medicare	0.30 (0.17-0.54)
Other	0.91 (0.33-2.50)
Uninsured/self-pay	0.81 (0.32-2.03)
ICF, intermediate care facility; LTC, long-term care or nursing home; SNF, skilled nursing facility	
*Only variables significant at $\alpha=0.05$ are included in the table.	
**Model Hosmer-Lemeshow goodness of fit test=0.54, area under the ROC curve=0.82.	

**THE IMPACT OF E-SCOOTER INJURIES ON A LEVEL I TRAUMA CENTER DURING INITIATION OF AN E-SCOOTER RENTAL PROGRAM: A CASE SERIES**

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**Introduction:** Electric motorized scooter (e-scooter) sharing programs have rapidly become a national and international phenomenon since being introduced in 2017. E-scooters are now available in 132 US cities and are easy to use, requiring only an app to get started. The popular press has heavily reported on e-scooters and subsequent injuries, but little research exists on potential injury risks and public safety. This study examined the burden of injuries resulting from e-scooter use on our trauma center by characterizing the number and severity of injuries in an extended case series.

**Methods:** Included patients sought treatment at our Level I trauma center ED for an e-scooter injury from July 1, 2018—the date e-scooters were introduced in our city—to January 31, 2019. Patients were identified using injury etiology keywords and chart review. Patient records and the trauma registry were queried for clinical variables and treatments rendered.

**Results:** 96 patients presented to the ED with e-scooter injuries, the first on July 4, 2018. None (0) wore a helmet, and 30.2% (29) reported alcohol use before riding or screened positive. Weekend (Fri, Sat, or Sun; 55.2%; 53) and at/after dark (1800-0600 hrs; 67.7%; 65) injuries predominated. Ages ranged 13-61. Most were <30 (52%; 50), and 7.3% (7) were <18. The total injuries by body region are outlined in the top table, with 50% (48) sustaining multiple injuries, and admission and treatment variables are outlined in the bottom table, where delayed presentations to the ED ranged from hours to a day post-injury. The injuries account for 66 hospital days and 9 ICU days total. Most ICU admits, including the death, were due to intracranial hemorrhage. 2 of the 3 abdominal injuries were Grade IV injuries. The most common treatments were laceration repair (37.5%; 36) and dislocation reduction (11.5%; 11).

**Conclusion:** While generally considered safe, e-scooters can pose a significant health risk. This case series likely represents only the tip of the iceberg as minor injuries likely bypass the ED and present to smaller, non-emergent clinics. These data relay the very real potential for serious injury with e-scooter use and emphasize the need for further study and injury prevention campaigns.

Injuries by Body Region	Patients
Extremity	62
Face	43
Head (TBI)	34
Hand or wrist	24
Extremity fractures	22
Isolated skin/soft tissue (not face)	18
Extremity dislocations	6
Head (SAH/SDH)	6
Spine	3
Chest	2
Abdomen	3
Variable	Patients
EMS Transport	33
Inpatient Admission	24
Inpatient Surgery	10
Delayed Presentation to ED	9
Trauma Team Activation	8
ICU Admission	8
Outpatient Surgery	5
Emergency Surgery on Admission	1
Mortality	1

**PARAMEDIC JUDGMENT FOR TRAUMA TEAM ACTIVATION:  
DOES IT IDENTIFY AT-RISK PATIENTS THAT ARE MISSED BY  
STANDARDIZED PRE-HOSPITAL TRIAGE PROTOCOLS?**

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**Introduction:** ACS-COT defines standard minimum criteria for full trauma team activation (TTA). In our system, discretion of pre-hospital personnel ('Paramedic Judgment' [PJ]) can initiate TTA in the absence of ACS-COT criteria. The goal of this retrospective cross-sectional study is to characterize the role of PJ for TTA in our hospital system when compared with standardized pre-hospital protocols.

**Methods:** All adult TTA transported by ground EMS to our Level I trauma center for the years 2015 and 2016 were included in data acquisition. Descriptive and bivariate comparisons were conducted between the two groups: 'Judgment'(J) vs 'Standard Criteria (SC) using a Wilcoxon sign-rank test for continuous measures (Age, ISS, LOS, Hospital Charges) and Fisher's exact test for categorical outcomes (Sex, Final Outcome, Disposition, and Injury Type). Overtriage rates, defined as full TTA with an ISS  $\leq 15$ , were calculated for each group.

**Results:** A total of 1977 patients were included in the final analysis. There was a significant difference between groups for gender, ISS, overtriage, mortality, discharge disposition and injury type amongst the J and SC groups. SC ISS was 1.31 times higher than the J group (95% CI: 1.14, 1.50), with overtriage 3.36 times greater in the J group (95% CI: 2.68, 4.23). The odds of survival were 46.8 times greater in the J group ( $p < 0.0001$ ; 95% CI: 19.2, 114.1). The odds of a discharge disposition to home were 2.95 times greater in the J group (95% CI: 2.41, 3.62). The odds of having a blunt injury were calculated to be 9.10 times greater in the J group (95% CI: 6.66, 12.44). In contrast, there was not a significant difference in distribution between groups for median age, length of stay or total hospital charges.

**Conclusions:** Patients triaged for full TTA by PJ experienced less significant injuries and substantially lower mortality than those activated by standard criteria. Despite this, there was no difference in total hospital charges between the groups suggesting that a significant portion of these charges occur during this initial phase of hospital evaluation. These notable differences suggest that the use of paramedic judgment as the sole rationale for TTA may place an undue financial burden on individual paramedic-triaged patients, and an overuse of resources for the hospital system.

	Paramedic Judgment	Standard Criteria	p value
Injury Type (Blunt [vs Penetrating])	700 (n=749, 93.5%)	719 (n=1177, 61.1%)	p< 0.0001
Over-Triage Rate (ISS $\leq 15$ )	633 (n=751, 84.3%)	743 (n=1209, 61.5%)	p< 0.0001
Mortality	5 (n=759, 0.7%)	273 (n=1215, 22.5%)	p< 0.0001
Discharge Disposition to Home or Jail	528 (n=715, 73.8%)	562 (n=1150, 48.9%)	p< 0.0001
Injury Severity Score (Median ISS)	8	10	p= 0.005
Length of Stay (Median days)	3	3	p> 0.05
Total Hospital Charges (Median Dollars)	\$35,780.70	\$36,840.63	p= 0.3750

## **MAPPING THE INCREASING INTEREST IN ACUTE CARE SURGERY – WHO, WHY AND WHICH FELLOWSHIP?**

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### **Introduction:**

Interest in Acute Care Surgery (ACS) has increased over the past 10 years as demonstrated by the linear increase in fellowship applicants. Fellowships facilitating entry into ACS careers include: one-year surgical critical care (SCC) and two year programs with the second year either accredited by the American Association for the Surgery of Trauma (AAST) or a non-AAST-accredited second year. It is unclear why the overall interest in ACS has increased, whether these three fellowships attract different applicants or whether fellowship choice correlates with practice patterns after graduation.

### **Methods:**

An online survey was distributed to individuals previously registered with the Surgical Critical Care and Acute Care Surgery Fellowship Application Service (SAFAS). Collected data included demographics, clinical interests and career motivations as well as post-fellowship work setting, work load and type and publication volume. Program directors of SCC, ACS and non-AAST two-year fellowships were asked to forward the survey to current and former fellows to increase the response rate. The survey was open for 2 months. Pearson's chi-square and Fisher's exact tests were conducted to analyze differences across fellowship types. Responses to open-ended questions were analyzed, grouped and reported using frequency data.

### **Results:**

Trauma surgery was the primary clinical interest for all fellowship types (n = 273), although SCC fellows were equally interested in surgical critical care. Career motivations were nearly identical across fellowship types with the most popular responses being "ability to care for the sickest patients" (97.1%) and "enjoy complex problem-solving" (92.3%). Fellowship trainees within the past 10 years were more likely to indicate "predictability of schedule" as having a strong influence on career choice (9.7% vs 42.6%), a trend which continues when looking only at respondents currently in training (51.9%). Regardless of fellowship type, respondents reported the same benefits for a second year of fellowship: graduated progression to full responsibility, further exposure to trauma care and additional operative technical training. Most respondents who have completed fellowship work in Level 1 trauma centers though fewer than 20% spend more than half of clinical time on trauma. Most reported 36 or more weeks of clinical service per year. Few had time reserved for scholarly activities and elective surgery was uncommon. Type of fellowship had no impact on these clinical or scholarly activities.

### **Conclusion:**

Current trainees in ACS are more likely to consider predictability of schedule as a significant factor in career choice. Otherwise, there were no differences in clinical interests, career motivations, clinical practice or scholarly output between 1-year SCC, and 2-year AAST, and non-AAST fellowships. Future research should focus on variability in trauma training and operative experience during residency to better inform how a second fellowship year would improve training for a career in ACS.

**PREDICTING THE FUTURE IN GERIATRIC TRAUMA: COMPARISON BETWEEN THE GERIATRIC TRAUMA OUTCOMES SCORE III (GTOSIII), ASCOT, AND TRISS IN ESTIMATING LONG-TERM MORTALITY RISK IN THE ELDERLY**

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**Introduction:** The GTOS score was originally designed to predict inpatient geriatric trauma mortality and has been validated in a multicenter trial. Recently the GTOSIII was created to predict 1-year mortality. We hypothesized GTOSIII would have superior test characteristics to predict 1-year mortality than similar trauma specific predictive scores: TRISS and ASCOT.

**Methods:** Our ACS verified level 1 trauma center registry was queried from 2001-2013 for patients age  $\geq 65$  years, who were then matched to the Social Security Death Index. GTOSIII is the formula:  $[GTOS\ III = Age + (0.55 * ISS) + 37.7(\text{if initial } GCS \leq 10) + 11.3(\text{if transfused in first 24 hours}) + 67.8(\text{if adverse discharge})]$ . Tests were compared for 1-year mortality prediction by misclassification rates, Brier scores, Tjur-R2, receiver operator curves, and area under the curve (AUC).

**Results:** There were 3,262 patients in the population. Inpatient mortality was 9.8% (322) and increased each year: 516(15.8%) one, 581(17.8%) two, and 738(22.7%) five years. GTOSIII had superior test characteristics (AUC of 0.868, Brier score of 0.09, Tjur R2 of 0.46 and misclassification rate of 12.6%), compared to TRISS (AUC of 0.744, Brier score of 0.12, Tjur R2 of 0.11 and misclassification rate of 14.7%) and ASCOT (AUC of 0.758, Brier score of 0.11, Tjur R2 of 0.20 and misclassification rate of 13.5%). The overlay of test ROC is displayed in the figure. GTOSIII had statistically better discrimination compared to ASCOT (Estimate 0.124, 95% CI 0.098-0.150;  $p < 0.0001$ ) and TRISS (0.110, 0.085-0.135;  $p < 0.0001$ ).

**Conclusion:** Geriatric patients have high rates of mortality following trauma both in and out of the hospital. GTOSIII is the optimal prediction tool for giving patients and families guidance on long-term outcomes.

## The Impact of Historical Racism on Modern Gun Violence: Redlining in the City of Louisville, KY

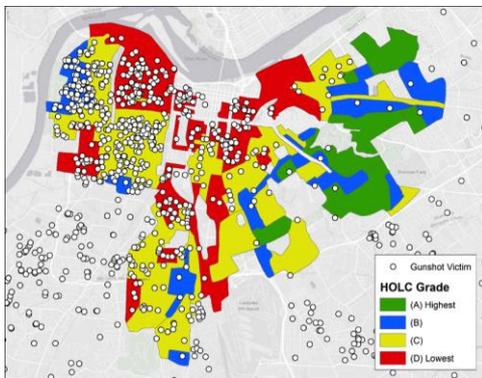
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**Introduction:** The Home Owner’s Loan Corporation (HOLC) was created in 1933 to support real estate investment during the Great Depression. Residential security maps were created to guide investment in over 200 US cities. Neighborhoods were assigned grades of ‘A’ through ‘D’ (with corresponding color coding of green, blue, yellow and red) to indicate desirability for investment. African American, immigrant, and low-income neighborhoods were frequently assigned grades of ‘C’ or ‘D’, effectively eliminating access to credit for investment. This process has since become known as “redlining”, owing to the color-coding on the security maps (now referred to as “redlining maps”). The impact of disinvestment endures in areas of many US cities today. We hypothesized that there would be a correlation between redlined areas on the 1937 map of Louisville, KY to the prevalence of gun violence today.

**Methods:** Gunshot victims (GSV) and their residential addresses within the city of Louisville were examined between 2010-2017. GSVs were aggregated within census blocks to approximate neighborhoods. The spatial distribution of GSVs was analyzed against the original HOLC neighborhood grade. Additional control variables adapted from the 2013-2017 American Community Survey were included to account for other possible explanations for the spatial distribution of GSVs. A zero-inflated negative binomial regression was used to determine incidence rate ratios (IRR) for the relative likelihood of GSVs within neighborhoods.

**Results:** IRRs for the HOLC grades as well as the control variables are seen in the table. The 1937 HOLC map with super-imposed GSVs from 2010-2017 can be seen in the figure. Relative to green-graded neighborhoods, yellow-graded neighborhoods had 5 times as many GSVs and red-graded neighborhoods had more than 6 times as many GSVs. Both of these differences were statistically significant.

**Conclusion:** Redlined neighborhoods within Louisville, KY in 1937 had significantly more GSVs today. The impact of historical and institutional racism on modern gun violence merits acknowledgement and further study.



**Table 1: Results of binomial regression**

	IRR	z-score
<b>HOLC Grade</b>		
Green (A)	(ref)	(ref)
Blue (B)	2.89	(1.71)
Yellow (C)	5.00 **	(2.64)
Red (D)	6.24 **	(2.97)
% Age 15-24	0.99	(-0.85)
% Non-Hispanic Black	1.02 **	(10.29)
% Hispanic	1.03 *	(2.30)
% in Poverty	1.01	(1.40)
% Vacant Housing	1.02 *	(2.42)
Population Density	1.00	(1.01)
Number of Observations	312	

\* p<0.05, \*\* p<0.01, \*\*\* p<0.001

**DOES THE PRESENCE OF 24-HOUR IN-HOUSE TRAUMA SURGEON COVERAGE HAVE A MEASURABLE IMPACT ON TRAUMA PATIENTS TREATED AT A COMMUNITY HOSPITAL?**

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**Introduction:**

The initiation of level II trauma centers in urban areas may optimize resource utilization in the care of trauma patients. We examined the impact of 24-hour in house trauma surgeon coverage at a community hospital in active pursuit of level II status to determine if improved coverage affected overall trauma volume, injury severity of patients admitted, and transfers to a higher level of care (HLOC). Prior to this, trauma patients were cared for by community general surgeons taking call at this facility.

**Methods:**

A retrospective review of consecutive trauma patients admitted to a community hospital before (Pre: 11/1/2016-10/31/2017) and after (Post: 11/1/2017-10/31/2018) initiation of 24-hour in-house trauma surgeon coverage. Patients <18 years of age and burns were excluded. Continuous data are presented as median (IQR) and compared using a Wilcoxon rank sum test. Categorical data were compared using Chi-Square. The rate of transfers for HLOC was evaluated using an interrupted time series to account for secular trends.

**Results:** Overall adult trauma volume increased by 24%, from 1,422 (119 patients/month) to 1,935 (149 patients/month). There was an increase in patients with penetrating injuries (Pre 10% vs. Post 16%,  $p<0.001$ ) and in the Injury Severity Score for admitted patients (Pre 5 [4, 10] vs. Post 9 [4, 10],  $p=0.002$ ). The number of operative interventions directly from the emergency department also increased (Pre 8% vs. Post 11%,  $p=0.004$ ). The percentage of transfers decreased (Pre 11% vs. Post 5%,  $p<0.001$ ) as did the number of transfers for a HLOC (graph).

**Conclusion:** We report a significant increase in the number and severity of injury of trauma patients admitted to our community hospital after initiation of 24-hour in-house trauma surgeon coverage. Additionally, there was a significant increase in the number of operative interventions direct from the ED and a concomitant decrease in the number of patients transferred for a HLOC—indicating that placement of trauma programs in high volume community hospitals results in patients receiving care sooner and in their local area.

**POSTER 71 WITHDRAWN**

## TOO MUCH TXA? FIBRINOLYSIS IS NOT COMMON AT PRESENTATION FOR PATIENTS IN AN URBAN LEVEL 1 TRAUMA CENTER

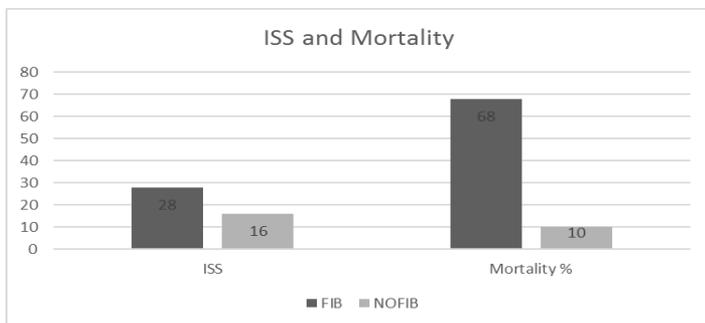
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**Introduction:** Recent studies have advocated for tranexamic acid (TXA) for all trauma patients early in their injury timeline. However, TXA has known complications, especially thromboembolic events. Our aim in this study was to assess the true incidence of fibrinolysis in an urban Level 1 trauma center where transport times are often short, but also includes rural transfers.

**Methods:** We queried our Level 1 trauma database for all admitted or deceased blunt or penetrating patients that had a finished rotational thromboelastography measured at the time of activation since introduced in 2013. In addition we collected available data on ISS, mortality and other outcomes. We used Lysis Index 30 – Extrinsic (LI30) less than 85% as evidence of fibrinolysis. Data was compared using standard statistical methods.

**Results:** There were 2215 patients who had a LI30 with activation. Only 47 (2.2%) had evidence of fibrinolysis. All but 6 of those had  $ISS \geq 15$ . Comparing those who were fibrinolytic (FIB) to those who were not (NOFIB), we found that FIB had a much higher mortality rate (10% vs 68%  $p < 0.0001$ ) and ISS (28 vs 16,  $p < 0.0001$ ). There was no statistical difference in percent penetrating trauma (49 vs 42,  $p = .36$ ) in the two groups.

**Conclusion:** Most patients presenting to an urban level 1 trauma center are not fibrinolytic and may not benefit from TXA for treatment of fibrinolysis. Treatment of fibrinolysis should be focused on those with highest risk, such as those with the highest injury burden or severity of bleeding. Further studies should be done to best determine which patients may benefit from its use, but routine TXA use should be carefully considered given the low rate of fibrinolysis in this population.



**NOVEL APPLICATION OF A DATA ADAPTIVE ‘VIRTUAL CLINICAL TRIAL’: STATISTICAL MODELING OF TEG GUIDED TRANSFUSION INTERVENTIONS**

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**Introduction:** The American College of Surgeons TQIP Best Practice Guidelines for the management of transfusion in trauma recommend thromboelastography (TEG) guided transfusion of plasma, platelets, and cryoprecipitate where TEG is available. However, given the paucity of randomized controlled trials of TEG guided resuscitation combined with significant barriers and little equipoise to pursue such trials, there remains variable adoption of TEG guided transfusion protocols across trauma centers. We sought to perform a data adaptive ‘virtual clinical trial’ using statistical modeling to intervene on a large population of trauma patients from a Level 1 Trauma Center in whom TEG was not used clinically. We hypothesized that statistical intervention with modeled transfusions based on TEG parameters would improve predicted hemostasis and mortality in this population.

**Methods:** Computational modeling was performed on data from 1671 trauma patients who were enrolled in a prospective observational cohort study and had TEG performed for research purposes only. Hypothetical transfusions based on TEG parameters were modeled (controlling for injury [ISS], shock [SBP, base deficit, heart rate], gender, age, race, and mechanism). A semiparametric data-adaptive modeling procedure that combines machine learning and causal inference (Targeted Learning) estimated the average treatment effect (ATE) for hemostasis (defined as no further blood transfusion) and mortality at 6hrs. TEG guided transfusion was pre-defined as: 2 units of plasma for activated clotting time (ACT)>128, 10 units of cryoprecipitate for alpha-angle<65 degrees, and 1 unit of platelets for maximum amplitude (MA)<55mm.

**Results:** The cohort was moderately injured (median ISS 14, IQR 4-27) with a 5% mortality at 6hrs. Protocolized platelet transfusion resulted in an adjusted 13% increase in 6hr hemostasis ( $p < 0.01$ ), but no significant decrease in mortality. Protocolized plasma transfusion resulted in an adjusted 11% increase in 6hr hemostasis and a 17% decrease in 6hr mortality (both  $p < 0.01$ ). Protocolized cryoprecipitate transfusion resulted in an adjusted 20% increase in 6h hemostasis and a 16% decrease in 6hr mortality (both  $p < 0.01$ ; Table).

Table. Adjusted Estimated Average Treatment Effect (ATE) for Hemostasis and Mortality Using TEG-Guided Resuscitation				
	ATE for 6h Hemostasis	p	ATE for 6h Mortality	p
2 units of plasma for activated clotting time (ACT)>128	11%	<0.01	-17%	<0.01
1 unit of platelets for maximum amplitude (MA)<55mm	13%	<0.01	-14%	0.15
10 units of cryoprecipitate for alpha-angle <65 degrees	20%	<0.01	-16%	<0.01

**Conclusion:** Using a data adaptive ‘virtual clinical trial’, we identified that institution of TEG guided transfusion in a large population of trauma patients markedly improves hemostasis and survival at 6hrs after injury. This novel technique of targeted machine learning fit toward specific parameters related to interventions allows adaptive estimation under very few assumptions producing robust inference, and may be the in-silico future of clinical trials.

## LIQUID PLASMA: A SOLUTION TO OPTIMIZING EARLY AND BALANCED PLASMA RESUSCITATION IN MASSIVE TRANSFUSION

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**Introduction:** Early and balanced plasma resuscitation, plasma to red blood cell (RBC) ratio >1:2, for major trauma victims in hemorrhagic shock is associated with decreased mortality. With a narrow window to optimize resuscitation parameters and mitigate preventable trauma mortality, timely plasma administration is imperative. However, in the actively hemorrhaging patient, a 20 minute thaw time for fresh frozen plasma (FFP) can result in delayed administration, and the 5 day shelf life of thawed FFP limits supply and incurs wastage if it cannot be repurposed. Liquid plasma (LP) offers an attractive alternative as it can be immediately transfused and has a 26-day shelf-life. As such, we hypothesized that the use of LP in the massive transfusion protocol would improve optimal plasma:RBC ratios in the traumatically injured.

**Methods:** Using Trauma Quality Improvement Program data from our level one trauma center we evaluated patients with massive transfusion protocol (MTP) activations from 2016-2018. Implementation of type A LP as the initial resuscitation plasma was instated April 2017. Prior to this, thawed FFP was solely used. Plasma:RBC ratios at 4 hours and 24 hours from hospital arrival were compared in MTP patients pre-LP and post-LP implementation. Baseline demographics, mechanism of injury (blunt vs penetrating) and injury severity score were accounted for using regression analysis. Secondary outcomes included mortality, length of stay and complications (acute kidney injury, acute respiratory distress syndrome, venous thromboembolism, and infectious).

**Results:** A total of 96 patients were included (pre-LP=39; post-LP=56). Post-LP plasma:RBC ratios at 4 hours and 24 hours were improved compared to pre-LP ratios, even after adjusting for potential confounders. Hospital length of stay and incidence of acute kidney injury were reduced in the post-LP group by 47% and 89%, respectively. This effect remained even on multivariate analysis. Hospital mortality was not different between groups. Importantly, no post-LP patients with blood group type B or AB (n=9) demonstrated evidence of hemolysis within 24 hours of transfusion with type A LP.

	Pre-LP (n=39)	Post-LP (n=56)	P-value
Age, mean [SEM]	34 [2.2]	35 [2.1]	0.77
Gender, % male (n)	90 (35)	86 (48)	0.76
ISS, mean [SEM]	29 [2.2]	33 [2.0]	0.17
Injury Mechanism, % penetrating (n)	85 (33)	70 (39)	0.14
<b>4-Hour Transfusion</b>			
Plasma:RBC, mean [SEM]	1:2.0 [0.051]	1:1.5 [0.055]	<b>0.037</b>
<b>24-Hour Transfusion</b>			
Plasma:RBC, mean [SEM]	1:1.9 [0.055]	1:1.3 [0.062]	<b>0.014</b>
<b>Hospital LOS (d), mean [SEM]</b>	32 [2.4]	17 [2.4]	<b>0.004</b>
<b>ICU LOS (d), mean [SEM]</b>	15.4 [3.57]	11.3 [2.14]	0.31
<b>Complications % (n)</b>			
AKI	18 (7)	2 (1)	<b>0.0076</b>
ARDS	13 (5)	5 (3)	0.27
VTE/PE	8 (3)	2 (1)	0.30
Infectious	26 (10)	11(6)	0.09
<b>Hospital Mortality % (n)</b>	36 (14)	43 (24)	0.53

LP= Liquid plasma; SEM= Standard error of the mean; ISS = Injury Severity Score; RBC= packed red blood cells; LOS= Length of stay; ICU = intensive care unit, AKI= acute kidney injury; ARDS= acute respiratory distress syndrome; VTE/PE= venous thromboembolism/pulmonary embolism.

**Conclusion:** Initial resuscitation with LP optimizes early plasma administration and improves adherence to transfusion ratio guidelines. Furthermore, LP offers a solution to inherent delays with FFP obviates ABO incompatibility and improves outcomes (reduced hospital LOS, AKI). LP should be considered as an alternative to FFP in MTPs.

## ACTIVE CPR IS THE BIGGEST PREDICTOR OF NEED FOR CUT-DOWN DURING REBOA PLACEMENT

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**Introduction:** While resuscitative endovascular balloon occlusion of the aorta (REBOA) has emerged as a less-invasive alternative to open aortic occlusion, the procedure requires swift and safe insertion of the cannula into the common femoral artery. This study seeks to identify the independent risk factors of the need for cut-down compared to percutaneous access in REBOA.

**Methods:** This retrospective observational study includes all patients in the American Association for the Surgery of Trauma (AAST) Aortic Occlusion for Resuscitation in Trauma and Acute Care Surgery (AORTA) Registry who underwent REBOA from November 2013 to June 2018. We examined predictors of utilization of and outcomes between open cut-down versus percutaneous techniques (with or without ultrasound guidance). High-volume centers were defined as 20+ REBOAs during the study period.

**Results:** Of 396 patients who underwent REBOA, 88 (22.2%) had initial placement via a cut-down. There was no difference in mean patient weight (85.5 vs. 82.9 kg,  $p=0.402$ ) or mean body mass index (27.8 vs. 27.4,  $p=0.731$ ) among patients with percutaneous vs. cut down. On logistic regression, predictors of cut-down access included active CPR (OR 11.5,  $p<0.001$ ) and attending vs. trainee placement (OR 4.1,  $p=0.043$ ), while patients age 40+ had lower odds compared to patients age <26 (OR 0.4,  $p=0.023-0.036$ ). On logistic regression, active CPR was predictive of failure of balloon occlusion (OR 0.23,  $p=0.005$ ), as was BMI 25-30 compared to BMI <25 (OR 0.17,  $p=0.039$ ); method of REBOA access, age, sex, BMI, center volume, and trainee status were not predictive of failure of balloon occlusion.

**Conclusion:** Although high-volume centers and attendings seem to perform more cut-downs than percutaneous approaches, the biggest predictor was active CPR. Weight and BMI did not factor in the decision or success to place a REBOA via an open or percutaneous approach.

**IN FLIGHT EARLY DECISION MODEL PREDICTS THE NEED FOR CRITICAL ADMINISTRATION THRESHOLD (CAT) AND MASSIVE TRANSFUSION (MT) FOLLOWING TRAUMA**

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**INTRODUCTION:** It is critical to recognize the need of large volume blood transfusion such as CAT ( $\geq 3$  U of blood in 1st hour) or MT ( $\geq 10$  U of blood in the 1<sup>st</sup> 24 hour) especially for trauma patient. The photoplethysmographic PPG waveform has been shown reasonable prediction results. We hypothesized that combination the field PPG with ECG would be more accurately predict the emergency blood transfusion needs.

**METHODS:** Helicopter transferred adult trauma patients admitted to a Level I trauma center from 2014-2017 were retrospectively enrolled. The real-time continuous in flight (field) PPG and ECG waveforms were collected at 250Hz. Over 100 waveform features such as heart rate variability, entropy, etc. were calculated for the first 10 min and the entire helicopter transfer. PPG or ECG alone and PPG+ECG based decision tree models were evaluated for prediction of CAT and MT. Area under receiver operating characteristic curve (AUROC) was used to evaluate predictive power. Delong's method compared AUROCs;  $p < 0.05$  was considered statistically significant.

**RESULTS:** We analyzed 2364 patients with over 886 million continuous in-flight ECG and PPG data points. Patients were predominantly male (60.2%), with mean age of  $46.9 \pm 20$  years. Average air transfer time was  $28.3 \pm 9.3$  min. Among all patients 7.6% received CAT, and 4.2% received MT. The model that used PPG and ECG was significantly better than individual PPG or ECG models. Models based on PPG were significantly better than models of ECG in predicting CAT and MT. AUROCs for using 10 min in flight combination of PPG+ECG, PPG, ECG for predicting CAT were 0.80, 0.72, 0.64; predicting MT with AUROCs 0.81, 0.73, 0.63. Using entire in-flight duration data of PPG+ECG, PPG, ECG, AUROCs for predicting CAT were 0.82, 0.75, 0.66; predicting MT with AUROCs 0.84, 0.76, 0.70. Predictive power (AUROC) were significantly improved with longer duration of waveform monitoring for both outcomes.

**CONCLUSION:** Automated analysis of combined field PPG and ECG waveform will further improve transfusion prediction and assist early identification of hemorrhage.

**Is “golden hour” still a cornerstone of trauma care for hemodynamically unstable patients?**

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**Introduction:** Elapsed time from the occurrence of injury to definitive care is considered as a determinant for mortality in patients with trauma. The concept of the “golden hour”, suggesting that critically injured patients are required to receive definitive care within 60 min, has been global consensus since the 1970s<sup>1</sup>. However, there is conflicting evidence to support it. Moreover, trauma care has been remarkably developed for the last two decades. Thus, we hypothesized that 60 min was not an appropriate cut-off time in the current trauma care settings. The objective of this study was to revise the exact association between time from injury to definitive care and mortality, particularly in hemodynamically unstable patients.

**Methods:** We analyzed the Japan Trauma Data Bank, which is a nationwide hospital-based registry of patients with trauma who were admitted to emergency hospitals in Japna, between 2004 and 2015. The inclusion criteria were adult patients who presented with hemodynamically unstable status (systolic blood pressure [SBP] < 90 mmHg and heart rate [HR] > 110 beats/ min, or SBP < 70 mmHg) who underwent definitive care within five hours from the onset of injury. The outcome measure was in-hospital mortality. First, patients who received definitive care at 60 min or less were matched with those who received care after 60 min using propensity score (PS) matching. The survival outcome of two groups were compared using a chi-square test and log rank test. Second, we evaluated the relationship between time to definitive care and outcome with the generalized additive model (GAM) in all participants. Further analysis was conducted after stratifying the patients according to severe shock status (SBP < 70mmHg) and moderate shock status (70 ≤ SBP < 90 mmHg and HR > 110 beats/ min) status.

**Results:** A total of 804 patients were enrolled in this study. After PS matching, no significant difference was observed in terms of mortality between patients who received definitive care ≤ 60 min and those who received care > 60 min (odds ratio 0.96; 95% confidence interval 0.34 – 2.4; P = 0.92). In addition, the log-rank test showed no significant difference between the curves of the two groups (P = 0.90) (Fig 1). The GAM models in all participants showed that the odds of mortality remained stable for the first 150 min (Fig 2A). In the subgroup analysis, the severe shock group presented with a paradoxical decline of mortality with increasing time (Fig 2B), whereas the moderate shock group had a time-dependent increase in mortality up to 180 min (Fig 2C). No threshold effect at 60 minutes was observed in all analyses.

**Conclusion:** Initiating definitive care within 60 min did not have a significant effect on the survival outcome of hemodynamically unstable patients. However, this was likely an offset result of severe and moderate shock groups. A shortened time to definitive care may be most beneficial for patients with moderate shock.

Figure 1. Kaplan-Meier survival curves for patients who had time to definitive care more than 60 minutes and less than 60 minutes.

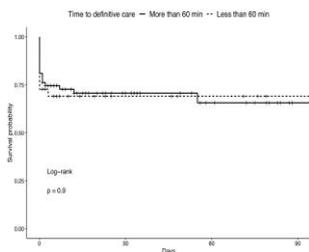
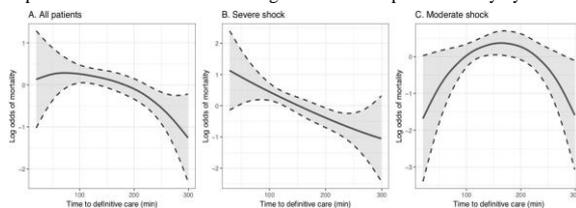


Figure 2. Nonparametric curves for trend of log odds of in-hospital mortality by the time to definitive care



(A, total patients, n = 804; B, severe shock patients, n = 421; C, moderate shock patients, n = 383).

**Reference:**

1. Cowley, R. A. (1975). A total emergency medical system for the State of Maryland. *Maryland State Medical Journal*, 24(7), 37-45

**Delaying Intubation Until Operating Room Arrival Reduces Transfusion Needs**

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**Introduction:** Post intubation hypotension occurs in hypovolemic trauma patients. We compared emergency department intubation (EDI) to operating room intubation (ORI) in trauma patients requiring surgery hypothesizing ORI could improve outcomes.

**Methods:** Retrospective analysis performed at a Level I Trauma Center between Dec/14

and Jan/18 of all adult torso trauma patients who underwent surgery. We excluded patients intubated prior to ED arrival. ERI patients were propensity score (PS) matched to ORI patients based on age, severity of brain and chest injuries (AIS>3), blunt trauma and the presence of tachypnea. The PS estimated the probability that a patient would have had ERI given baseline characteristics. The primary outcome, in-hospital mortality was examined using multivariable logistic regression (MLR). The secondary outcome was the amount of packed red blood cells transfused in the first six hours after arrival which was assessed by multivariable quantile regression (MQR).

Variable	ERI (n=58)	ORI (n=265)	p-value
Age, median (IQR)	25 (33-44)	22 (27-35)	0.003
Penetrating Trauma			<0.001
GSW, n (%)	28 (48.3%)	190 (71.7%)	
SW, n (%)	9 (15.5%)	55 (20.7%)	
Initial SBP, median (IQR)	85 (50-113)	105 (80-122)	0.001
Initial HR, median (IQR)	102 (78-123)	98 (80-116)	0.4
Patients with SBP<90, n (%)	29 (50%)	85 (32%)	0.01
Severe TBI**, n (%)	26 (44.8%)	20 (7.5%)	<0.001
ISS, mean (SD)	25 (25-33)	25 (16-25)	<0.002
PRBCs first 6 h, median (IQR)	4 (2-7)	2 (0-4)	<0.001
Massive Transfusion*, n (%)	10 (17.2%)	17 (6.4%)	0.007
Laparotomy, n (%)	38 (65.5%)	206 (77.7%)	0.05
Abdominal Damage Control, n (%)	20 (34.5%)	87 (32.8%)	0.8
Thoracic Incision, n (%)	24 (41.4%)	75 (28.3%)	0.05
Thoracic Damage Control, n (%)	11 (18.9%)	19 (7.1%)	0.005
Solid Organ Injury 2grade 4, n (%)	23 (39.6%)	56 (21.1%)	0.003
Mortality at the OR, n (%)	11 (18.9%)	17 (6.4%)	0.002
In-hospital mortality, n (%)	25 (43.1%)	27 (10.2%)	<0.001

Variable	ERI (n=58)	ORI (n=58)	p-value
Age, median (IQR)	33 (25-44)	31 (26-42)	0.59
Penetrating Trauma			0.3
GSW, n (%)	28 (48.2%)	29 (50%)	
SW, n (%)	9 (15.5%)	14 (24.1)	
Initial SBP, median (IQR)	85 (50-113)	85 (52-112)	0.89
Initial HR, median (IQR)	102 (78-123)	101 (79-118)	0.5
Patients with SBP<90, n (%)	29 (50%)	33 (56.9%)	0.4
Severe TBI**, n (%)	26 (44.8%)	18 (31.1%)	0.1
ISS, mean (SD)	25 (25-33)	25 (22-29)	0.6
PRBCs first 6 h, median (IQR)	4 (2-7)	3 (0-5)	0.03
Massive Transfusion*, n (%)	10 (17.2%)	7 (12.1%)	0.4
Laparotomy, n (%)	38 (65.5%)	38 (65.5%)	1
Abdominal Damage Control, n (%)	20 (34.5%)	21 (36.2%)	0.8
Thoracic Incision, n (%)	24 (41.4%)	25 (43.1%)	0.8
Thoracic Damage Control, n (%)	11 (18.9%)	6 (10.3%)	0.1
Solid Organ Injury 2grade 4, n (%)	23 (39.6%)	19 (32.7%)	0.4
Mortality at the OR, n (%)	11 (18.9%)	13 (22.4%)	0.6
In-hospital mortality, n (%)	25 (43.1%)	15 (25.8%)	0.051

\*Glasgow<8, \*\*>10 units of PRBCs

All regression analyses were performed within matched cohorts. **Results:** A total of 323 patients were included. ERI- and ORI patients were similar after matching (Table1). In non-matched cohorts, mortality was significantly higher in the ERI group (43.1% vs. 10.2%; p<0.001); however, in-hospital mortality was not significantly different after PS matching (EDI: 43.1% vs. ORI: 25.8%; p=0.051). MLR controlling for hypotension, units of PRBCs at six hours, need of aortic occlusion, and ISS showed no significant differences in the odds of death with ERI (OR 2.49, 95% CI 0.89-6.97). MQR adjusted by hypotension, penetrating trauma and heart rate>120 showed that ERI was associated with a greater need for PRBC transfusion (coef: 2, 95% CI 0.51-3.4). **Conclusion:** Delaying intubation until to allow for immediate hemorrhage control may reduce the need for PRBC's transfusion. Further prospective studies are required.

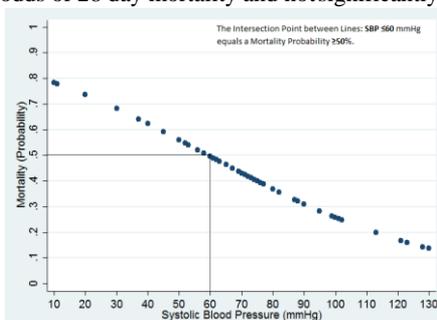
## THE TIMING AND VALUE OF AORTIC OCCLUSION IN TRAUMA PATIENTS IN PROFOUND HEMORRHAGIC SHOCK BUT NOT YET DEAD: 60 MMHG MIGHT BE TOO LATE

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**Introduction:** This study aimed to evaluate the optimal timing for application of Aortic Occlusion (AO) in all its forms in trauma patients in profound hemorrhagic shock.

**Methods:** All adult patients (age >15 years) undergoing AO via Resuscitative Balloon Occlusion of the Aorta (REBOA) and/or Emergency Department Thoracotomy (EDT) between 2014 and 2018 at a regional Level I Trauma Center were included. Patients who required CPR in the pre-hospital setting were excluded. A logistic regression analysis based on cardiac arrest, REBOA/EDT, mechanism of injury and systolic blood pressure (SBP) were conducted. **Results:** A total of 107 patients underwent AO, 84 (88%) were males and the median age was 31 (IQR: 23-41). Sixty patients (56%) who underwent AO developed traumatic cardiac arrest (TCA) and 47 (44%) did not. EDT was performed in 57 (53%) and REBOA in 50 (47%). There was a higher proportion of penetrating trauma among both groups [TCA=54 (90%), No-TCA=35 (74%);  $p<0.05$ ] and their injury severity were similar [TCA=ISS: 25 (IQR: 25-33) vs No-TCA=ISS: 25 (IQR: 25-34);  $p=0.68$ ]. Vital signs on arrival to the ED were higher in the No-TCA group [No-TCA=SBP: 70 mm Hg (IQR: 58-88), Heart Rate (HR): 113 bpm (IQR: 97-132) vs TCA=SBP: 50 mmHg (IQR: 0-76), HR: 89 bpm (IQR: 0-120);  $p<0.001$ ]. All patients were found to have profound acidosis [No-TCA=Base deficit: -10 (IQR: -17 to -5), TCA=Base deficit: -13 (IQR: -23 to -7);  $p=0.07$ ] and similar median intra-operative hemorrhage [TCA= 3500 mL (IQR: 2000-4100), No-TCA=3000 mL (IQR: 2000-4000);  $p=0.29$ ]. The overall 24-hour and 28-day mortality was 50 (47%) and 56 (52%), respectively. On sub-analysis using logistic regression adjusted for TCA we found that the type of aortic occlusion (REBOA vs EDT) was not associated with a significant reduction in the odds of 28 day mortality [OR=0.61, (95%CI: 0.15-2.46);  $p=0.49$ ]. Furthermore, TCA was found to be an independent variable associated with higher odds of 28 day mortality and not significantly modified by the presence of an AO [OR=15.72, (95%CI: 5.07-48.68);  $p<0.001$ ]. There were no significant differences when the analysis was adjusted by mechanism of injury [OR=0.28, (95%CI: 0.07-1.11);  $p=0.07$ ]. However, we found that for each 10 mmHg that the SBP increased the odds of mortality decreased significantly by 20% [OR=0.98, (95%CI: 0.97-0.99);  $p<0.05$ ] and that when the declining SBP reached the value of 60 mmHg or less, the probability of death is greater than 50% in each case.

**Conclusion:** A SBP of 60 mmHg or less indicates that AO must be performed immediately prior to the development of TCA. We found that even with AO, the risk of death after TCA is not reduced in trauma patients suffering from profound hemorrhagic shock.



## SHOCK INDEX AS A PREDICTOR OF MASSIVE TRANSFUSION AND EMERGENT SURGERY ON THE MODERN BATTLEFIELD

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**Introduction:** Shock Index (SI) has been used to predict need for massive transfusion (MT) and emergent surgical procedures (ESP) in civilian trauma. SI has not been evaluated in the battlefield setting, where penetrating and blast injuries predominate and rapid triage decisions are critical. We hypothesize that SI can reliably identify casualties that will require MT and ESP when applied to the resource-constrained, combat environment.

**Methods:** Retrospective review of the DoD Trauma Registry (2008 to 2016). SI was calculated using heart rate and systolic blood pressure upon arrival to the initial facility with surgical capabilities. A threshold value of 0.8 was used to stratify patients into two groups (Group I,  $SI < 0.8$  and Group II,  $SI \geq 0.8$ ). The need for MT ( $\geq 10U$  blood products in 24 hrs), large volume transfusion (LVT, 4-9U in first 24 hrs), ESP, and mortality were compared. Regression analyses were conducted to determine the independent association of SI with MT and ESP.

**Results:** 4,008 patients were included, mean age 25.5 years and predominately male (98%). Mechanisms of injury were blunt/blast injury (62%), penetrating injury (36.7%) and burn injury (0.5%). A total of 77% (3070) were stratified to Group I and 23% (938) Group II by SI. Group II patients had greater need for LVT, MT, and ESP and significantly higher mortality rates (Table 1). The negative predictive value of  $SI \geq 0.8$  for MT and ESP was 99.6% (Area under the Curve,  $AUC=0.829$ ) and 93.5% ( $AUC=0.703$ ), respectively. Regression analysis controlling for age, gender, ISS, and GCS confirmed that  $SI \geq 0.8$  was an independent risk factor for both MT and need for emergent surgical procedures ( $p < 0.001$ ).

Variable	Group I ( $SI < 0.8$ )	Group II ( $SI \geq 0.8$ )	p-value
Large Vol Transfusion, % (n)	1.1 (33)	14.0 (131)	<0.001
Massive Transfusion, % (n)	0.4 (11)	8.4 (79)	<0.001
Emerg Surg Procedure, % (n)	6.5 (200)	30.7 (288)	<0.001
Mortality, % (n)	0.7 (20)	4.6 (43)	<0.001

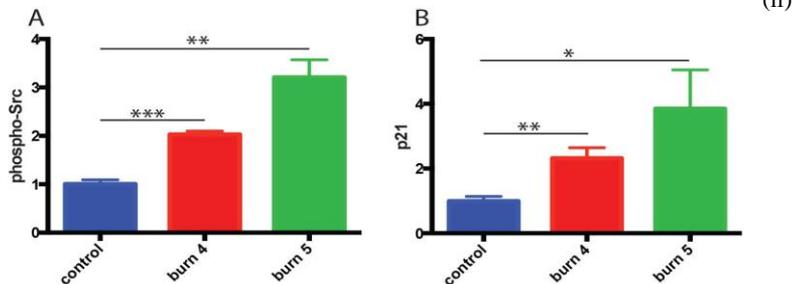
**Table 1.** Comparison of Outcomes by Shock Index

**Conclusion:** Shock Index is a significant predictor of the need for massive transfusion and emergent surgical procedures in the military trauma population, representing a simple and potentially potent tool for triage and prediction of resource consumption in the resource-limited, austere setting.

## ENDOTHELIOPATHY, DAMP RELEASE AND LEUKOCYTE SIGNALING CHANGES IN SEVERE BURN PATIENTS

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**Introduction:** Despite recent improvements in burn resuscitation, the endotheliopathy associated with burn injury remains poorly understood. In this pilot study, we analyzed the following characteristics in blood samples obtained from 14 severely burned patients: (i) release of Damage Associated Molecular Patterns (DAMPs);



**Figure 1.** ActivSignal IPAD analysis demonstrates the elevation of Src phosphorylation (A) and p21 level (B) in burned patients mononuclear leukocytes

syndecan-1 levels; and (iii) cell signaling in leukocytes. **Methods:** The citrated blood samples were obtained at <24h, 24-48h and 8d after burn. Blood from healthy donors served as a control. Platelet-free plasma was isolated from the samples. Mononuclear leukocytes were isolated by centrifugation of the buffy-coat over Lymphoprep. The plasma content of a major DAMP, mitochondrial DNA (mtDNA) was determined by qPCR. As a major characteristic of endotheliopathy, the plasma level of shed endothelial glyocalyx protein syndecan-1 was determined by ELISA. The signaling in leukocytes was studied using the ActivSignal IPAD platform that enables the simultaneous analysis of major cellular signaling pathways. Leukocytes from two randomly chosen patients at <24 h after burn injury, and one healthy donor were used for the signaling portion of the study. **Results:** All burn patients (n=14, %TBSA burn average= 31.6%; Range= 19% - 56%) exhibited significant increase of plasma mtDNA and syndecan-1 at all studied time points. mtDNA content increase varied from 2 to 130 times over the healthy level. Syndecan-1 increase was mostly between 2 and 15 times. Three of 14 patients died, and two of these three patients showed at day 8 an extremely high syndecan-1 plasma content, more than 30 times higher than healthy control. The IPAD signaling analysis demonstrated that at <24h after burn injury, the leukocytes of two studied patients (both survivors) had an increased level of Src protein phosphorylation and p21 expression which is indicative of inflammation and possibly leukocyte genome protection under stress conditions respectively. **Conclusion:** Severe burn injury in humans results in endotheliopathy, massive mtDNA release and characteristic changes in leukocyte cell signaling. Further study of severe burn patients with analysis of additional DAMPs and glyocalyx components, and more extensive analysis of lymphocyte signaling is warranted.

**NOT JUST AN ACADEMIC VARIABLE: SHOCK INDEX IS A PREDICTOR OF INJURY PATTERN, SEVERITY AND LIKELIHOOD OF BLOOD PRODUCT TRANSFUSION IN AUTO-PEDESTRIAN TRAUMA**

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**Introduction:** Auto-pedestrian traumas comprise a wide spectrum of trauma admissions and require rapid triage. Shock index (SI) has been studied as a physiologic variable in trauma and has been correlated with outcomes and mortality. We sought to determine the ability of early SI following auto-pedestrian trauma to identify injury patterns, severity and blood product use.

**Methods:** A single level 1 trauma center's trauma registry was retrospectively reviewed for auto-pedestrian trauma for a 5 year period (2014-2018). Patients were stratified by SI > 0.9 or ≤ 0.9. Injuries, mortality, injury severity score (ISS), anatomic injury score (AIS), blood product use, ICU length of stay (LOS) and Hospital LOS

were compared between SI groups. Results are reported as median or percent incidence, statistical analysis was done using Kruskal-Wallis or Pearson's  $\chi^2$  with  $p < 0.05$  as significant.

**Results:** 107 patients were identified and analyzed. Patients with SI > 0.9 had more thoracic injuries (33% vs. 11%,  $p = .02$ ) and a higher median ISS (19.5 vs. 8.5,  $p = .009$ ), higher incidence of AIS > 3 (40% vs. 12%,  $p = 0.009$ ), higher incidence of transfusion (47% vs. 8%,  $p < .0001$ ), and longer hospital length of stay (9 vs. 3 days,  $p = .015$ ) than patients with SI ≤ 0.9.

**Conclusion:** These results indicate the ability of early shock index > 0.9 to discern injury pattern and, more importantly, injury severity, blood product use and hospital LOS in auto-pedestrian trauma. These findings warrant further elucidation and we are actively investigating the use of shock index in the triage and trauma level determination of auto-pedestrian trauma at our institution.

	Subjects with Shock Index > 0.9 (n=15)	Subjects with Shock Index ≤ 0.9	P Value
ISS (median)	19.5	8.5	0.009
AIS > 3	40%	12%	0.006
Incidence of Transfusion	47%	8%	<0.0001
ICU LOS (median)	8.5 days	3 days	0.145
Hospital LOS (median)	9 days	3 days	0.015
Mortality	7%	2%	0.328

## TRANSFUSING THROUGH THE YEARS: HOW AGE AND NEED FOR BLOOD TRANSFUSION RELATE TO MORTALITY

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**Introduction:** Age and the need for massive transfusion are independent predictors of morbidity and mortality in trauma patients. We hypothesized the combination of increasing age and high volume transfusion results in progressively elevated mortality rates. **Methods:** The Trauma Quality Improvement Program (TQIP) database was queried from 2013-2016 to evaluate the mortality rates based on age and blood transfusion. Subsequently, a retrospective review of a level I trauma center registry for all trauma patients from 2013-2017 was performed. Patients were grouped by decade of life and packed red blood cell (pRBC) transfusion within 4 hours of admission: zero units, 1-2 units as minimal requirement, or  $\geq 4$  units as massive transfusion. Demographics, laboratory values, mortality and length of stay (LOS) were compared. These variables were analyzed independently as well as in a multivariate logistic regression model to predict mortality. **Results:** Mortality rates from the TQIP database demonstrated a significant increase with age regardless of 24 hour pRBCs transfusion. In multivariate analysis, 24-hour mortality risk demonstrated reduced risk of death in age group 40- 49, but increased risk of death in age groups 70-79 and 80+. The 24-hour mortality risk was increased by each unit of pRBCs given in the first 24 hours and increased heart rate, but higher systolic blood pressure (10 mmHg increments) and GCS were protective. By contrast, the 30-day mortality risk demonstrated a linear relationship with increasing age and the administration of pRBCs, vital signs and GCS demonstrated a similar relationship to risk of death at 24 hours. (Table) Due to the lack granularity in the TQIP database, we reviewed 7240 patients from our institution. 88% of patients did not require pRBCs, 7% required 1-2 units pRBCs, and 5% received  $\geq 4$  units pRBCs within 4 hours of admission. Mortality rates were significantly increased in older adults in both the cohort that did not receive any pRBCs ( $p < 0.0001$ ) and in the group that received  $\geq 4$  units of pRBCs ( $p < 0.0001$ ). Among patients that received  $\geq 4$  units pRBCs at our institution, younger patients had significantly higher heart rates and lactate levels, and worse base deficits compared to older patients, while there were no differences among age groups in GCS, ISS, total blood product transfusion, or LOS. **Conclusion:** Although 30-day mortality increases with age in massively transfused patients, a significant proportion of older adults are successfully resuscitated. Therefore, age alone should not be considered a contraindication to high volume transfusion. Physiologic and lab criteria of hemorrhagic shock may have reduced reliability with increasing age. However, these data demonstrating increased risk of death by decade with transfusion after injury can be utilized to help counsel patients and families regarding mortality risk after trauma.

Variable	24 Hour Mortality OR (95% CI)	30 Day Mortality OR (95% CI)	Mortality for $\geq 4$ units local data
Age Range			
18-29 (reference)	1.00	1.00	31.6%
30-39	0.91 (0.82-1.01)	0.98 (0.91-1.07)	28.4%
40-49	0.86 (0.77-0.95)*	1.16 (1.07-1.26)*	31.7%
50-59	0.95 (0.85-1.05)	1.50 (1.39-1.62)	37.2%
60-69	1.11 (1.00-1.24)	2.00 (1.85-2.17)*	44.0%
70-79	1.37 (1.22-1.54)*	2.85 (2.62-3.10)*	45.5%
80 and up	1.42 (1.26-1.60)*	3.38 (3.12-3.68)*	62.5%
SBP (10 mmHg increment)	0.92 (0.91-0.93)*	0.95 (0.94-0.95)*	
HR (10 beat increment)	1.07 (1.06-1.08)*	1.06 (1.05-1.07)*	
GCS Total	0.82 (0.82-0.83)*	0.82 (0.82-0.82)*	
pRBCs in first 24 hours (1 unit increment)	1.08 (1.08-1.08)*	1.10 (1.10-1.10)*	

Data presented as Odds ratio (95% confidence interval); \* =  $p < 0.05$

**LIFE THREATENING HEMORRHAGE WHOLE BLOOD VOLUME REPLACEMENT UTILIZING THE W.A.T.C.H.E.R. METHOD**

Douglas Pokorny DO, Maxwell Braverman DO, Philip Edmundson MD, David Bittenbinder MD, Christian McEvoy MD, Mallory Wampler MD, Ashley McGinity MD, Leslie Greebon MD, Michael Shiels RN, Rachelle Babbitt Jonas RN, Brian Eastridge\* MD, Susannah Nicholson MD, Ronald Stewart\* MD, Donald Jenkins\* MD, University of Texas Health Science Center at San Antonio

**Introduction:** Massive transfusion protocols (MTP) classically focus on replacing a specific quantity of units of blood but not on addressing volume of hemorrhage. Focusing on “units” transfused over an arbitrary timeframe can be extremely variable as unit volume differs by center and product type. Massive Transfusion (MT) is currently undefined when using whole blood (WB) for resuscitation. Our aim was to examine all trauma patients in our facility who underwent MT involving the use of WB looking for a more specific cutoff for defining life threatening hemorrhage.

**Methods:** A retrospective review of all trauma patients at our urban level one trauma center transfused between January 1, 2015 and December 31, 2018 was performed. Data collected included patient demographics, vital signs, transfusion volumes/times, disposition times/locations and all lab values collected at our facility. Prisoners, pregnant patients and pediatric patients were excluded. Patients receiving primarily WB were then compared to patients receiving component based therapy (CBT) alone.

**Results:** Review of our data revealed a rate of MT which was lower than expected after initiation of our WB program. Patients had similar vitals signs, shock index, hematocrit and 30 day mortality rates (Table 1). Sixty percent of WB MTP mortalities occurred at 4 units or 2000 ml transfused in the first 24 hours. Sixty percent of CBT MTP mortalities occurred at 6 units or 2000ml in that time period. After expanding our definition of MT to include >3U of whole blood or >1500ml of combined products in 24 hours our total number of MTP patients increased to the expected level based on historic data.

**Conclusion:** Severity of hemorrhage may be underrepresented when applying the classic definition of MT to patients receiving WB. Though our net units of WB transfused compared to CBT was lower, the actual volume of transfusion was equal. The mortality associated with

>3U of whole blood or >1500ml of total product is equivalent to the mortality seen with the classic definition of MTP. The use of this definition should help eliminate survivor bias in early mortality for future studies. With the resurgence of whole blood we propose the adoption of a new nomenclature: the Whole Blood Approach to Transfusion in Critical Hemorrhage and Emergency Resuscitation (W.A.T.C.H.E.R.) method. This is the first study in the modern whole blood era to redefine classic MTP.

	COMPONENT (N = 270)	WHOLE BLOOD (N=62)	p-VALUE
AGE (yrs)	38.5	44	0.286
WEIGHT (kg)	81.6	88.1	0.002
GENDER (M/F)	188 / 82	59 / 3	0
RACE (wrt/blk/asian/other)	237 / 22 / 3 / 7	55 / 2 / 0 / 5	0.101
SHOCK INDEX	1.14	1.18	0.945
HEMATOCRIT	35.9	36.4	0.599
HOSPITAL DAYS	3.5	8.5	0.1357
OVERALL MORTALITY	139 (51.5%)	28 (45.1%)	0.369

**Table 1. Comparison of patient demographics and mortality rates using the new (W.A.T.C.H.E.R.) definition of massive transfusion.**

## COAGULOPATHY CORRECTION WITH FRESH FROZEN PLASMA: HOW MUCH DO WE REALLY NEED TO TRANSFUSE?

Nicholas P. Rottler MD, Navpreet Dhillon\* MD, Andrew Wang MD, Galinos Barmparas\* MD, Eric Ley\* MD, Cedars-Sinai Medical Center

**Introduction:** Thromboelastography (TEG) had been used to assess coagulopathy in order to guide transfusion of fresh frozen plasma (FFP), platelets, and cryoprecipitate. However, the effect of FFP on the correction of TEG R time is not well established, leading clinicians to correct coagulopathy without a predictable response on subsequent TEG studies. We sought to quantify the effect of plasma administration on the correction of the TEG R time to serve as a guide for future coagulopathy correction.

**Methods:** All surgical ICU patients between Aug 2017 and Feb 2019 with at least two TEGs performed over three consecutive days that noted R time correction due to FFP were included in the analysis. An improvement was defined as a decrease in the initial R time by 1.8 min or greater, with initial abnormal R time ranging between 9.5 and 17 min. The medical records were reviewed for plasma administration between the TEGs. The association of FFP administration on R time was then assessed.

**Results:** Thirty-six surgical ICU patients over the 17-month study period who met inclusion criteria were identified. The mean age of the group was 59 years, 63.9% were male, mean APACHE score was 81.3, and the mortality rate was 52.8%. The majority of patients (72.2%) consisted of cirrhotic pre-liver transplant patients. The mean interval between TEGs was  $830 \pm 598$  minutes, the mean initial R time was  $10.93 \pm 1.69$  minutes, the mean FFP transfused was  $1.88 \pm 0.97$  units, and the mean R time correction was  $3.54 \pm 1.54$  minutes. We determined that for every unit of FFP provided the R time was reduced by  $1.89 \pm 1.01$  minutes.

**Conclusion:** TEG can successfully guide blood component replacement when attempting to correct coagulopathy. The administration of FFP leads to a predictable response in subsequent TEG studies with one unit of FFP improving R time by about 2 minutes. This finding may help optimize the administration of FFP for coagulopathy correction.

### Gender Differences in the Massively Transfused Trauma Patient

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**Introduction:** Recent studies have suggested the female hypercoagulable state may have a protective effect in trauma. However, whether this hypercoagulable profile confers a survival benefit in massively transfused trauma patients has yet to be determined. We hypothesized that females would have better outcomes than males after traumatic injury that required massive transfusion protocol (MTP).

**Methods:** All trauma patients that underwent MTP at an urban, level 1, academic trauma center were reviewed from November 2007 to October 2018. Female MTP patients were compared to their male counterparts.

**Results:** There were a total of 643 trauma patients undergoing MTP. Of these, 90 (13.8%) were female and 563 (86.2%) were male. Presenting blood pressure, heart rate, shock index, and injury severity score (ISS) were not significantly different. Overall mortality and incidence of venous thromboembolism (VTE) were similar. Complication profile and hospital stay were similar. On logistic regression, female gender was not associated with survival (HR: 1.04, 95%CI: 0.56-1.92, p=0.91). Variables associated with mortality included age (HR: 1.02, 95%CI: 1.05-1.09, p=0.03) and ISS (HR: 1.07, 95%CI: 1.05-1.09, p<0.001). Increasing GCS was associated with survival (HR: 0.85, 95%CI: 0.82-0.89, p<0.001). On subset analysis, pre-menopausal women (age<50) did not have a survival advantage in comparison to similar aged males (HR: 0.68, 95%CI: 0.36-1.28, p=0.24). However, on subset analysis, each unit of blood transfused, conferred a mortality risk for males, but not females (table).

**Conclusion:** Gender differences in coagulation profile may result in lower mortality risk for females per unit of blood when MTP is required.

Logistic Regression Examining Variables Associated with Mortality			
	Odds Ratio	95% Confidence Interval	p Value
Subset Analysis of Females Only			
Age	0.99	0.96-1.03	0.59
Injury Severity Score	1.04	0.99-1.08	0.06
Presenting Systolic BP	1.01	0.98-1.04	0.55
Presenting Shock Index	2.35	0.36-15.20	0.37
GCS	0.85	0.76-0.96	0.01
Each Unit pRBC	1.02	0.99-1.01	0.24
Subset Analysis of Males Only			
Age	1.02	1.01-1.04	0.004
Injury Severity Score	1.07	1.05-1.10	<0.001
Presenting Systolic BP	0.99	0.99-1.01	0.62
Presenting Shock Index	0.65	0.32-1.30	0.22
GCS	0.84	0.80-0.88	<0.001
Each Unit pRBC	1.02	1.01-1.04	0.004

**TRANSFUSION OF WHOLE BLOOD FOR CIVILIAN TRAUMA PATIENTS: PRELIMINARY REPORT ON COAGULATION CAPACITY AND OUTCOMES**

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**Introduction:** Military services have found that whole blood (WB) offers a survival advantage over component therapy (CT). Initial civilian studies and preclinical work suggest hemostatic capacity of WB may be superior to CT, though it remains to be seen whether this will translate into clinical relevance. Here we report preliminary findings from an ongoing single-institution prospective observational study of WB vs CT for initial resuscitation of civilian trauma patients.

**Methods:** Adult male trauma patients presenting with systolic blood pressure < 100 triggering massive transfusion protocol activation were eligible to receive up to 4 units of low titer (anti-A/B) group O+ WB leukoreduced with a platelet-sparing filter (WB group). Adult trauma patients meeting the same inclusion criteria who received CT as initial resuscitation served as controls. Blood for thromboelastography (TEG) was drawn on admission and after resuscitation was complete with either medical or surgical hemostasis. All hypothesis tests were two-sided with alpha=0.05.

**Results:** Twenty-three male patients received WB as initial resuscitation followed by additional CT as needed, compared to 27 controls who received CT alone (18 male, 9 female; sensitivity analysis showed no significant differences in coagulation profile when females were excluded). There were no significant differences in age, injury mechanism, ISS, ABC score, or BMI between groups. There were no transfusion reactions or positive direct antibody tests.

**Conclusion:** Initiating resuscitation for traumatic hemorrhage with WB leukoreduced with a platelet-sparing filter resulted in post-resuscitation TEG profiles which were normal on average and similar to those seen with CT as initial resuscitation. Patients transfused with CT and WB received similar total volumes of blood product and had similar clinical outcomes.

**TEG parameters before (0h) and immediately after resuscitation (AR), median (IQR)**

Variable	CT, 0h (n = 23)	WB, 0h (n = 22)	p	CT, AR (n = 22)	WB, AR (n = 19)	p
R (min, nml 5-10)	4 (3.3-4.6)	3.8 (3.1-4.4)	0.74	4.6 (3.8-6)	5 (4.4-5.8)	0.30
K (min, nml 1-3)	1.8 (1.2-2.1)	2 (1.2-2.2)	0.44	2.3 (1.8-2.7)	2 (1.4-2.6)	0.48
Angle (deg, nml 53-72)	65.9 (64.2-70.9)	67.7 (62.7-73.4)	0.60	63.5 (57.1-64.2)	63.4 (55.4-72.3)	0.56
MA (mm, nml 50-70)	62.9 (56.4-66.1)	60.7 (52.7-68.3)	0.79	55.2 (51.9-59.5)	56 (51.5-61.9)	0.62

**Blood Product Transfusion 4h after Admission and Clinical Outcomes, median (IQR)**

Variable	Component therapy (n = 27)	Whole blood (n = 23)	p
WB units (n)	0 (0-0)	2 (1-3)	<0.001
Platelets/PRBC ratio	0.6 (0-1.2)	0.5 (0-1.2)	0.88
FFP/PRBC ratio	0.7 (0-0.8)	0.7 (0-0.8)	0.776
Total Volume of Products (mL)	3050 (1187.5-4512.5)	2287.5 (1612.5-3400)	0.748
30 day Mortality (n)	5 (18.5%)	1 (4.5%)	0.204
ICU Stay (days)	7 (4-11)	4.5 (2.2-9.8)	0.146

## REFINING THE MASSIVE TRANSFUSION PROTOCOL PHENOTYPE: IMPLICATIONS FOR PERSONALIZED RESUSCITATION

Anamaria J. Robles MD, Lucy Z. Kornblith MD, Amanda S. Conroy RN, Mitchell J. Cohen\* MD, Rachael A. Callcut\* MD, MSPH University of California, San Francisco

**Introduction:** Massive transfusion protocol (MTP) activation usually occurs based upon physician gestalt despite the availability of multiple massive transfusion prediction scores. The aim of this study was to compare all MTP activations resulting in significant transfusion (MTP+) to MTP activations ultimately not receiving significant transfusion (MTP-) to determine if there was a predictable phenotype to allow refinement of activation criteria.

**Methods:** A prospective cohort of highest level trauma activations from 2010-2016 were analyzed for demographics, initial vital signs, standard coagulation labs, rotational thromboelastometry (ROTEM: EXTEM and FIBTEM), and outcomes between MTP+ and MTP-. MTP activations were cross referenced with the blood bank records.

**Results:** 1378 patients were enrolled with 257 (18.7%) having MTP activated and 83/257 (32.3%) receiving >10 units of blood products in 24 hours (MTP+). Comparing all MTP activations, the MTP+ group were more likely female, bluntly injured, with worse ISS and BD and lower SBP. All clotting parameters by ROTEM were also worse (Table). Overall mortality for MTP activations was 33.5% with 64% (55/86) of the deaths occurring in <24 hours. There were no differences in hospital days, ICU days, or pneumonia; however, MTP+ patients were more likely to have MOF (p=0.009) and fewer vent-free days (p=0.0001).

Parameter	MTP-	MTP+	p-value
Female	15.0%	25.3%	0.045
Blunt	40.8%	60.2%	0.004
ISS	22	38	0.0001
GCS	14	12	0.0001
BD	5.3	7.3	0.0197
SBP	123	111	0.0075
HR	107	115	0.06
PTT	28.3	37.5	0.0001
INR	1.2	1.4	0.0001
EXTEM CT	60.5	79	0.0014
EXTEM CFT	93	123	0.0014
EXTEM Alpha	72	68	0.0257
EXTEM MCF	62	55	0.0004
FIBTEM MCF	13	42	0.0049

**Conclusion:** Approximately 1/3<sup>rd</sup> of all MTP activations result in significant transfusion volumes. Laboratory assays that can be obtained rapidly at point-of-care including viscoelastic clot initiation parameters and blood gas base deficit differentiates those activations most likely to require significant transfusion from those resulting in fewer transfusions, and may be useful in improving massive transfusion prediction scores.

**GIVE THE SURGEON A CHANCE: INCREASED LENGTH OF SURVIVAL AND RATE OF TRANSFER TO THE OPERATING ROOM AFTER RESUSCITATION WITH WHOLE BLOOD**

Douglas Pokorny DO, Phillip Edmundson MD, Maxwell Braverman DO, David Bittenbinder MD, Christian McEvoy MD, Mallory Wampler MD, Ashley McGinity MD, Leslie Greebon MD, Michael Shiels RN, Rachele Babbitt Jonas RN, Susannah Nicholson MD, Brian Eastridge\* MD, Ronald Stewart\* MD, Donald Jenkins\* MD, University of Texas Health Science Center at San Antonio

**INTRODUCTION:** An effective massive transfusion protocol (MTP) has been shown to decrease mortality in the setting of life-threatening hemorrhage. In January of 2018, our hospital began transfusing whole blood (WB) in our trauma resuscitation unit (TRU). Analysis of our first year of WB transfusion suggests that in addition to an overall mortality benefit, WB transfusion may be associated with prolonged time to death (TTD) among patients who ultimately succumb to their injuries allowing more opportunities for life saving interventions.

**METHODS:** A retrospective review of all trauma patients at our urban level one trauma center transfused between January 1, 2015 and December 31, 2018 was performed. The population group was then narrowed to include only those patients that received emergency release blood in massive transfusion quantities initiated in the TRU. Prisoners, pregnant patients and pediatric patients were excluded.

**RESULTS:** A total of 268 patients were included. Age, Shock Index (SI), Injury Severity Score (ISS) and mechanism of injury were similar among both groups. 43 patients received WB as part of their resuscitation; 225 received component based therapy (CBT) alone. Median TTD in the WB group was significantly longer than CBT (5.38hrs vs 1.63hrs, p=0.034). Although WB patients had similar mortality in the TRU (11.6% vs 24.4%, p=0.06), similar rate of disposition to the operating room (OR) (65% vs 50%, p=0.07), and similar 30 day mortality (48.8% vs 53.8%, p=0.55), the trends suggest further accrual of patients may yield statistical significance (Table 1).

**CONCLUSION:** The addition of WB to our program shows prolonged patient survival (TTD), trends toward a reduction in post operative, TRU and 30 day mortality rates and an increased rate of disposition to the OR compared to patients who received CBT alone. Type II error does not allow definitive mortality conclusions at our current sample size. These findings suggest that introducing WB has given our surgeons almost four additional hours to combat the injuries and lethal hemorrhage with which they are faced and supports the implementation of a prospective, randomized, controlled trial.

	COMPONENT (N = 225)	WHOLE BLOOD (N=43)	p-VALUE
AGE (yrs)	37	44	0.578
WEIGHT (kg)	81.6	86.18	0.006
GENDER (M/F)	161 / 64	41 / 2	0
RACE (wt/blk/asian/other)	198 / 17 / 3 / 6	38 / 2 / 0 / 3	0.4
MECHANISM (P/B)	76 / 149	20 / 23	0.111
ISS	26	22	0.147
SHOCK INDEX	1.14	1.2	0.603
GCS	3	10	0.073
HCT	35.6	36.2	0.868
pH	7.22	7.28	0.075
HOSPITAL DAYS	2	7	0.324
30 DAY MORTALITY	121 (53.8%)	21 (48.8%)	0.552
TRU MORTALITY	55 (24.4%)	5 (11.6%)	0.065
DISPO TO OR	113 (50.2%)	28 (65.1%)	0.073
TTD (hrs)	1.63	5.38	0.034

**Table 1. Comparison between those receiving whole blood in their resuscitation and those receiving component based therapy alone.**

## **EFFECTS OF RESUSCITATION WITH FIBRINOGEN CONCENTRATE AND PLATELETS ON COAGULATION IN PIGS WITH REDUCED PLATELET COUNTS AND TRAUMATIC HEMORRHAGE**

Wenjun Z. Martini Ph.D., Andrew Cap\* MD,Ph.D., Michael Dubick\* Ph.D., US Army  
Institute of Surgical Research

When creating your abstract, the only section headers to be used are listed below, and they need to be in this format (please remove this line before creating your abstract):

**Introduction:** Damage control resuscitation emphasizes reducing crystalloids and providing hemostatic products, such as platelets and fibrinogen concentrate (FC), to treat patients with severe bleeding. This study compared resuscitation effects of platelets and FC on coagulation in pigs with traumatic hemorrhage and reduced platelet counts.

**Methods:** Thirty pigs ( $40 \pm 1$  kg) were anesthetized and catheterized with an apheresis catheter in the femoral vein to remove platelets using Haemonetics 9000. Afterwards, a femur fracture was induced using a captive bolt stunner, followed by hemorrhage of 35% of the estimated blood volume (24.5 ml/kg). Pigs were then randomized to be resuscitated with 5% human albumin (as control, 12.5 ml/kg, n=10), FC (RiaSTAP, 250 mg/kg, 12.5 ml/kg, n=10), or platelets collected from apheresis (n=10). Animal were then monitored for 2h or until death. Blood samples were collected before apheresis (baseline, BL), after apheresis, hemorrhage, and resuscitation to assess changes in coagulation, using Rotem<sup>®</sup> thrombelastogram. Hemodynamics were recorded during the sampling times.

**Results:** MAP, heart rate (HR) or cardiac output (CO) was not changed by platelet apheresis. Hemorrhage reduced MAP to  $57\% \pm 5\%$  and CO to  $55\% \pm 2\%$  of BL and elevated HR to  $212 \pm 20\%$  of BL (all  $p < 0.05$ ). Resuscitation with albumin, FC or platelets did not return MAP or HR to BL. Resuscitation with albumin returned CO to BL, but not with FC or platelets. Platelet counts were reduced by apheresis from BL  $383 \pm 20 \times 10^9/L$  to  $141 \pm 14 \times 10^9/L$  ( $p < 0.05$ ), and were reduced further after resuscitation with albumin ( $88 \pm 18 \times 10^9/L$ ) or FC ( $97 \pm 13 \times 10^9/L$ , both  $p < 0.05$ ), but improved with platelet resuscitation ( $307 \pm 24 \times 10^9/L$ ). Plasma fibrinogen concentration was reduced by apheresis from BL  $225 \pm 9$  mg/dL to  $194 \pm 8$  mg/dL ( $p < 0.05$ ), fell more after albumin infusion ( $134 \pm 11$  mg/dL), increased to  $269 \pm 10$  mg/dL after FC resuscitation ( $p < 0.05$ ), and was not affected by platelet resuscitation ( $203 \pm 8$  mg/dL). Rotem<sup>®</sup> Alpha angle (clotting speed) decreased from  $79 \pm 2^\circ$  to  $69 \pm 1^\circ$  by apheresis and hemorrhage ( $p < 0.05$ ), and recovered similarly by resuscitation with FC ( $87 \pm 1^\circ$ ) or platelets ( $78 \pm 2^\circ$ ), but not by albumin ( $63 \pm 3^\circ$ ). Similar response were observed in Rotem<sup>®</sup> Maximum clot firmness. There were no differences in changes Hct, RBC counts, or survival time among the 3 groups.

**Conclusion:** In this traumatic hemorrhage swine model of reduced platelet counts, low volume resuscitation with fibrinogen concentrate or platelets was similarly effective in restoring coagulation, compared to albumin.

**MULTI-ORGAN STRESS INDICATORS SIGNAL INCREASED LATE MORTALITY**

Bryan W. Carr MD, Xin Huang MD, Ben L. Zarzaur\* MD,MPH, John Sharpe MD, Stephanie A. Savage\* MD, MS Indiana Univesity School of Medicine

**Introduction:** Though hemorrhage and brain injury are the leading causes of immediate and early death following injury, late deaths are most commonly related to multi-organ failure and infection. Subtle clinical indicators may provide an early warning to clinicians of pending deterioration. We hypothesized that changes in ventilatory mechanics and lab values early in a patient’s hospital course would be predictive of later decompensation leading to mortality.

**Methods:**

This study involved a retrospective review of injured patients admitted to an intensive care unit at a Level 1 trauma center over a two year period. Ventilation, (Lung compliance (LC)) and Oxygenation (PaO2:FiO2 (P:F)), and metabolic stress (bicarbonate) were recorded daily for one week. As these values vary directly with metabolic stress, a Multi-organ Stress Index (MoSI) was derived as follows

$$MSI = LC (L/cmH2O) \times P:F \times bicarbonate.$$

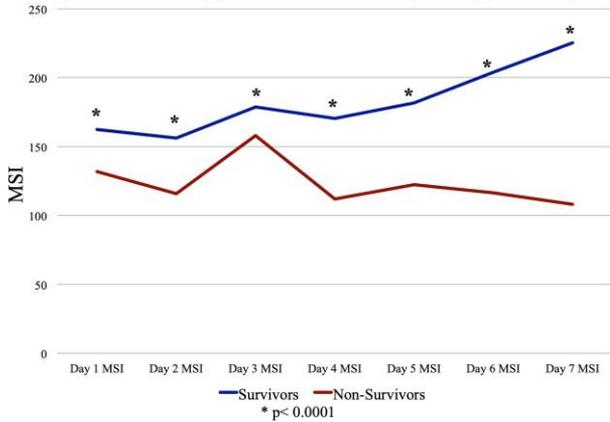
Wilcoxon Rank Sum was used to associate admission MoSI with overall mortality and daily MoSI was associated with corresponding daily mortality.

**Results:** 100 patients were included. There were no differences in patient demographics, injury mechanism, thoracic trauma or shock

index between survivors and non-survivors. Overall mortality was 34%. Admission MoSI was significantly lower for non-survivors (343.1 vs. 554.1, p<0.001). Daily MoSI remained significantly lower in non-survivors, and trended downward, compared to survivors (figure). Early decrements in MoSI, especially below 75, were associate with increased mortality compared to patients who maintained a higher MoSI (51.4% vs. 22.6% , p= 0.003).

**Conclusion:** Subtle changes in ventilatory mechanics and bicarbonate levels early in a patient’s hospital course indicate increased multi-organ stress and increased potential for clinical deterioration. Low MoSI was highly associated with mortality. Identification of low MoSI may be a trigger for earlier initiation of aggressive rescue therapies such as continuous renal replacement therapy or extra-corporeal membrane oxygenation.

**Fig 1. Multi-Organ Stress Index by Hospital Day**



## Direct measurement method is unreliable for proper placement of resuscitative occlusion balloon into the target zone of the aorta

Shokei Matsumoto\* MD, Tomohiro Funabiki MD, Taku Kazamaki MD, Taku Akashi MD, Motoyasu Yamazaki MD, Mitsuhide Kitano MD, Saiseikai Yokohamashi Tobu Hospital

**Background:** Resuscitative endovascular balloon occlusion of the aorta (REBOA) should be deployed at Zone 1 or 3 depending on the location of the hemorrhage. Ideally, the catheter position in REBOA deployment should be confirmed via fluoroscopy, but it is not common for trauma bays to be equipped with fluoroscopy. Therefore, some researchers have analyzed the aortic geometry and developed a fixed-distance model for using REBOA without fluoroscopy (ex: Zone 1 approx. 46 cm). Our hospital is one of the major trauma centers in Japan and has frequently used REBOA without fluoroscopy. The aim of this study is to describe our experience and evaluate the accuracy of positioning REBOA without fluoroscopy in a Japanese major trauma center.

**Methods:** A retrospective review identified all trauma patients who underwent a REBOA procedure and were admitted to our urban trauma center from 2008 to 2018. We do not use the fixed-distance method for determining REBOA positioning because there is significant variation within the population in terms of vascular anatomy. Instead, balloon positioning is determined with direct measurement of the sheath to the target zone part using the REBOA catheter (Fig. 1). The positioning, complications, and the bleeding source for REBOA were reviewed based on the radiological and surgical results. The decision and target zone in which to deploy REBOA was made by the attending emergency physician, a Japanese Association for Acute Medicine certified faculty member.

**Results:** During the study period, 38 patients met our inclusion criteria. The in-hospital mortality was 57.9%. Among the three patients who developed REBOA-related complications, one was critical. Nine patients switched from open aortic clamp to REBOA. With respect to the bleeding source, REBOA was frequently used in the abdominal (46.3%, n=19) and pelvic (34.1%, n=14) regions. Overall, the positioning rate of REBOA was 68.4% in Zone 1, 26.3% in Zone 2, and 5.3% in Zone 3. The concordance rate for the target zone was 79.2% in Zone 1 and 7.1% in Zone 3 (Table 1).

**Conclusions:** In many cases, the balloon was deployed at an untargeted zone using the direct measurement method, especially in Zone 3. The direct measurement method is therefore unreliable. For improving proper placement into the target zone, further studies including the fixed-distance model are needed.

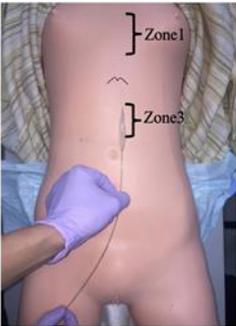


Fig 1.

Deployment zone	Target zone		
	Zone 1	Zone 3	Total
Zone 1	23 (82.1%)	3 (30.0%)	26 (68.4%)
Zone 2	4 (14.3%)	6 (60.0%)	10 (26.3%)
Zone 3	1 (3.6%)	1 (10.0%)	2 (5.3%)
<b>Total</b>	<b>28 (100%)</b>	<b>10 (100%)</b>	<b>38 (100%)</b>

Table 1.

## EARLY PREDICTORS OF MASSIVE TRANSFUSION IN PENETRATING TRAUMA

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### Introduction:

The presence of penetrating trauma and a positive FAST have been incorporated in the ABC score as independent parameters to predict the need for transfusion (MT). Other scores have been derived from military series or civilian cohorts with a low proportion of penetrating trauma. In order to more accurately determine the need for MT in penetrating trauma we sought to identify specific parameters in a civilian population with 100 % penetrating torso injuries (TPI).

### Methods:

Patients with TPI, 18 years and older, managed in a level-I trauma center were included. Variables obtained during the evaluation in the trauma bay were registered prospectively. The ability to predict MT was evaluated with simple, multiple logistic regressions (MLR) and ROC curves.

### Results:

We included 162 subjects; 137 (84.6%) received fire-arm wounds, and 144 (88.9%) were male. Twenty-one (13%) received MT.

Compared with the no-MT patients, those who received an MT were intubated more frequently in the pre-hospital, had lower SBP, higher HR, lower GCS and received more frequently vasopressors ( $p < 0.05$ ).

Trauma mechanism, localization, number the wounds, and positive FAST, could not discriminate MT ( $p > 0.05$ ).

Models were created with the variables identified as independent predictors of MT. They showed better discriminative ability than ABC score and adequate goodness to fit (table).

**Table. Evaluated Predictors of Massive Transfusion in Torso Penetrating Trauma**

Model	AUROC (95% C.I.)	Goodness of fit p
ABC score	0.7435 (0.64199 - 0.84501)	0.3291
SBP (mm Hg) +HR (beats/min) +GCS	0.8207 (0.73790 - 0.90344)	0.9614
SBP $\leq$ 90 mm Hg + HR $\geq$ 120 beats/min + GCS $\leq$ 14	0.8315 (0.75062 - 0.91233)	0.5011
SBP (mm Hg) + HR (beats/min) + Best Motor Response	0.8237 (0.74121 - 0.90621)	0.9639
SBP $\leq$ 90 mm Hg + HR $\geq$ 120 beats/min + Best Motor Response $\leq$ 5	0.8318 (0.75200 - 0.91163)	0.3139
AUROC Area under the ROC curve	SBP Systolic Blood Pressure	HR Heart Rate
		GCS Glasgow Coma Scale

**Conclusion:** Early identification of the risk of MT can accurately be made in TPI by a combination of SBP, HR and a clinical measurement of neurological impairment.

## INTEGRATION OF RESUSCITATIVE ENDOVASCULAR BALLOON OCCLUSION OF THE AORTA FOR HEMORRHAGE CONTROL IN THE SETTING OF PLACENTA ACCRETA SPECTRUM AND PERI-PARTUM HEMORRHAGE

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**INTRODUCTION:** Pregnancy-related mortality continues to increase throughout the US, with rates in several states surpassing that of third-world countries and reaching the level of a public health crisis. One of the causes of this increasing mortality is placenta accreta spectrum (PAS). PAS, an abnormal attachment of the placenta to the myometrium, places the mother at an increased risk of severe hemorrhage at the time of delivery. Given our experience with REBOA in the setting of non-compressible torso hemorrhage for trauma, we recently implemented a protocol for its use in cases of PAS. We present a review of the largest case series to date in the US of the implementation of the 7FR REBOA for hemorrhage control in the setting of PAS and peri-partum hemorrhage.

**METHODS:** We performed this descriptive case series of all REBOA (January 2018 – January 2019) placements at our center in scenarios of planned elective cesarean delivery in patients with known PAS and emergent REBOA deployment in the setting of acute peri-partum hemorrhage due to PAS. Baseline data, pathology, and outcomes were abstracted from our hospital's electronic medical record and our multidisciplinary performance improvement registry. Our Acute Care Surgery (ACS) Faculty placed all REBOA catheters. All patients had common femoral artery duplex 48-hours after sheath removal and clinic follow-up with the ACS team.

**RESULTS:** REBOA was performed in the setting of elective PAS delivery (n=10) and acute peri-partum hemorrhage (n=2). Average maternal age in years at the time of delivery was 34.5 (+/- 4.38), average gestational age in weeks was 33.55 (+/- 3.31), average gravidity was 5 (min 2, max 11) and parity 4 (min 1, max 9). Average estimated blood loss at the time of delivery was 2.1L. Overall survival was 92%, with the one death in an emergent setting from abruption and DIC. There was one access site complication requiring thrombectomy of the external iliac artery and one common femoral artery thrombus that subsequently resolved on repeat duplex. All surviving patients had normal pulse examinations at the time of their clinic follow-up.

**CONCLUSION:** Implementation of REBOA by Acute Care Surgeons as a part of a multidisciplinary team is feasible and facilitates hemorrhage control in patients with peri-partum hemorrhage related to PAS. REBOA use may lead to decreases in morbidity and mortality in the at-risk pregnant patient with PAS. Further studies are necessary to identify patient specific characteristics for the implementation of the 7FR REBOA for known PAS and in the event of peri-partum hemorrhage.

PATIENT	AGE	RACE	GRAVIDITY	PARITY	GESTATIONAL AGE (WKS)	BMI	EBL (cc)	FINAL PATH	COMPLICATION	EMERGENT
A	43	WHITE	3	2	34.86	26.9	2000	INCRETA	NONE	NO
B	34	WHITE	3	2	32.14	21.97	4500	INCRETA	Right External iliac artery thrombus requiring thrombectomy	YES
C	36	BLACK	2	1	34.1	37.06	1500	INCRETA	NONE	NO
D	34	HISPANIC	4	3	31	30	1500	INCRETA	Common Femoral Artery Clot on 48 hour duplex that resolved on repeat duplex without intervention	NO
E	32	WHITE	6	4	35.71	32.01	500	INCRETA	NONE	NO
F	31	WHITE	3	1	35.12	27.1	2500	ACCURETA	NONE	NO
G	41	WHITE	11	5	36.19	36.19	3600	INCRETA	NONE	NO
H	29	WHITE	7	3	34.71	37.3	2000	INCRETA	NONE	NO
I	29	WHITE	3	2	35.43	55	2200	INCRETA	NONE	NO
J	38	BLACK	10	9	34.29	43.58	6000	PERCRETA	NONE	NO
K	33	BLACK	4	3	34.86	55.54	1200	INCRETA	NONE	NO
L	34	WHITE	9	7	24.14	24.41	2500	INCRETA	Death	YES

**TRANEXAMIC ACID ADMINISTRATION DOES NOT COMPROMISE EARLY GRAFT PATENCY IN TRAUMA PATIENTS UNDERGOING ARTERIAL REPAIRS: AN ANALYSIS OF PATIENTS FROM THE AAST PROSPECTIVE OBSERVATIONAL VASCULAR INJURY TREATMENT (PROOVIT) REGISTRY**

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**Introduction:** Since 2010, there has been increased use of tranexamic acid (TXA) to reduce mortality in trauma patients with major bleeding. Previous studies with perioperative transfusions of TXA in coronary artery bypass grafts have shown no reduction in graft patency or increased thrombotic complications. However there have not been any studies investigating TXA and the rate of thrombosis in trauma patients undergoing vascular repairs. Our study investigated the relationship between TXA and in-hospital graft patency for trauma patients with vascular injuries undergoing arterial repairs.

**Methods:** We analyzed a subset of patients from the PROOVIT registry who underwent open or endovascular definitive arterial repair using a graft or stent. Patients who received TXA were compared to those who did not. The primary outcome of the study was in-hospital graft patency. Graft occlusion was defined by the need for repeat operations or interventions due to either thrombosis or stenosis of initial arterial repair. Data were analyzed using students t-test and  $\chi^2$  test.

**Results:** There were 898 cases of arterial injuries identified over 755 patients (4.6% cervical injuries, 30.4% torso injuries, 27.5% upper extremity injuries, and 37.5% lower extremity injuries). There were 100 cases in the TXA group, and 798 cases in the non-TXA group. There was no significant difference in the rate of graft thrombosis/stenosis between the TXA and non-TXA groups (10% vs 7%,  $p=0.26$ ). TXA administration was also not associated with an increased rate of distal ischemia (stroke, bowel ischemia, or extremity amputation) (10% vs 8.5%,  $p=0.62$ ). In the TXA group, graft occlusions most commonly occurred after repairs of brachial or femoral artery injuries. In the non-TXA group, graft occlusions most frequently occurred after popliteal artery repair. Arterial graft occlusion was only significantly associated with the need for immediate perioperative revision during the initial surgery (42% vs. 7%,  $p<0.0001$ ) and was unrelated to the use of TXA.

**Conclusion:** The administration of TXA did not compromise early graft patency in trauma patients undergoing arterial repairs. Although this study does not take into consideration time and dose of TXA in these high risk patients, clinicians should be comfortable administering TXA to trauma patients with arterial injuries without concern for increased risk of graft occlusion. Future research should factor in the time and dose of TXA in this high risk population.

## **OUTCOMES COMPARISON BETWEEN ENDOVASCULAR AND OPEN REPAIR (OR) FOR BLUNT THORACIC AORTIC INJURY (BTAI): A CONTEMPORARY ANALYSIS**

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**Introduction:** Thoracic endovascular aortic repair (TEVAR) results in improved outcomes compared to OR for BTAI, but information regarding cost and outcomes for patients treated without surgical intervention (NOP) are limited. Using a comparative effectiveness strategy, we aim to analyze outcomes, demographics and cost comparisons between TEVAR, OR, and NOP in a large, contemporary group of patients with BTAI.

**Methods:** The National Inpatient Sample (NIS) 2012-2014 was queried to identify patients with diagnosis and procedure codes corresponding to BTAI. Primary outcomes were mortality, length of stay (LOS), cost, and complications. Chi square, t-test, and multiple logistic regression analyses were used to identify differences between groups and risk factors for mortality.

**Results:** 3455 patients with the diagnosis of BTAI were identified; 1390 underwent TEVAR, 110 OR, and 1955 patients were treated non-operatively (NOP). Mean age was 42 ( $\pm$  18.75) years, most patients were male (74%), mean hospital length of stay was 14 ( $\pm$  19.9) days, and mean total cost was \$79,913( $\pm$ \$77673) covered by private insurance (including HMO) in 46%. The most common chronic medical diagnosis was hypertension (23%) followed by obesity (6.5%). 74% patients had an extreme likelihood of dying as calculated by the All Patients Refined Diagnosis Related Groups (APDRG) risk mortality scale. There was no difference in age, gender, and presence of co-morbid conditions between TEVAR and OR. TEVAR patients had higher rates of hemothorax ( $p=0.045$ ) and orthopedic injuries ( $p=0.014$ ) compared to patients treated by OR. There was no difference in rates of stroke, paraplegia, acute renal failure (ARF), or pulmonary complications between TEVAR and OR. Total cost was similar between groups, but TEVAR patients had a longer length of hospital stay than OR ( $p=0.02$ ). Total cost was significantly higher in OR and TEVAR patients compared to NOP ( $p<0.001$ ). Mortality was significantly higher in patients treated OR compared to TEVAR (36% vs 6%,  $p<0.001$ ). Advanced age, female gender, and OR were all significant predictors of mortality. On regression analysis OR was associated with a 17-fold increase in mortality compared to TEVAR ( $p<0.001$ ). Using age, gender, associated injuries and co-morbidities in the regression model, TEVAR had a lower mortality rate ( $p<0.001$ ) compared to NOP patients, while OR repair had a higher mortality rate compared to NOP ( $p=0.036$ ).

**Conclusion:** Most BTAI are managed non-operatively. For those who receive surgical treatment, the use of TEVAR has surpassed the use of OR and has become the standard of care. Even with a higher burden of thoracic and musculoskeletal injury in TEVAR patients, the survival rate for endovascular treatment of BTAI is significantly higher than OR, with comparable cost and complication rates. TEVAR also results in higher survival rates compared to patients managed non-operatively. It is unknown whether these significant outcomes are related to improvements in technology, operator experience, timing of interventions, critical care of patients with BTAI, or other factors.

## PREDICTION OF VENOUS THROMBOEMBOLISM USING CLINICAL AND SERUM BIOMARKER DATA FROM TRAUMA PATIENTS

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**Introduction:** Venous thromboembolism (VTE) is a frequent complication of trauma associated with high mortality and morbidity. Thromboprophylaxis has been shown to be effective at reducing VTE incidence. However, clinicians lack appropriate tools for stratifying trauma patients into risk cohorts for VTE. We aimed to compare two predictive models for VTE incidence using both clinical and serum cytokine biomarkers.

**Methods:** Data was collected from 73 military trauma patients with at least one extremity wound  $\geq 75$  cm<sup>2</sup> who were prospectively enrolled in an observational study between 2007 and 2012. Clinical data was collected from point of injury through to discharge. Initial serum cytokine data collection began at the first surgical debridement at a US treatment facility, which occurred a median of 5 days after injury. Modeling was performed with Random forests (RF) and Logistic regression (LR) based on the presence or absence of deep vein thrombosis (DVT) and/or pulmonary embolism (PE). RF modeling was performed, using backwards variable elimination as a feature selection method. LR was also performed on the final variables from the RF model. Model performance was assessed using leave-one-out cross-validation. Sensitivity/specificity were reported at the threshold where their product was maximized.

**Results:** Of 73 patients (100% male, median age=22 years, median ISS=16), nine patients (12.3%) developed VTE, including four (5.5%) with DVT, four (5.5%) with PE, and one (1.4%) with both. The incidence of VTE in our population is notably higher than male civilians of similar age (~4%). VTE was diagnosed at a median of eight days from injury. The final RF model included five variables (serum IL15, serum MIG, serum VEGF, units of total blood products at initial resuscitation, and presence of soft tissue injury) and had an area under the curve (AUC) of 0.946, sensitivity of 0.992, and specificity of 0.838. The LR model underperformed the RF model by comparison, with an AUC of 0.713, sensitivity of 0.672, and specificity of 0.776.

**Conclusion:** VTE may be predicted by clinical and molecular biomarkers in trauma patients. The current study requires subsequent external validation. This will allow for the development of clinical decision support tools (CDSTs) which can help inform the management of high-risk patients for VTE.

<b>Modeling Method</b>	<b>AUC</b>	<b>Sensitivity</b>	<b>Specificity</b>
<b>Random Forest</b>	<b>0.946</b>	<b>0.992</b>	<b>0.838</b>
<b>Logistic Regression</b>	<b>0.713</b>	<b>0.672</b>	<b>0.776</b>

## VAGUS NERVE STIMULATION REGULATES ARACHIDONIC ACID PRODUCTION IN THE MESENTERIC LYMPH AFTER INTESTINAL ISCHEMIA REPERFUSION INJURY.

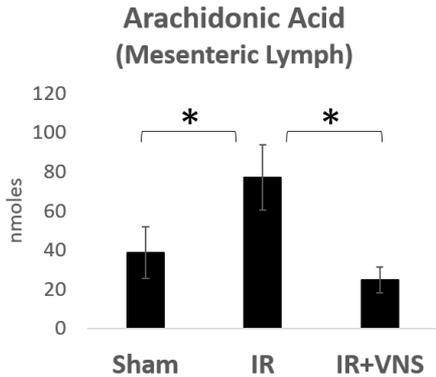
Masayuki Yagi MD, Koji Morishita\* MD,Ph.D., Mitsuaki Kojima MD,Ph.D., Atsushi Senda MD, Sanae Doki MS, Beth Taylor MS, Yurika Shinjyo BS, Tetsuyuki Kobayashi Ph.D., Junichi Aiboshi MD,Ph.D., Yasuhiro Otomo\* MD,Ph.D., Tokyo Medical and Dental University

**Introduction:** Previous studies have shown that mesenteric lymph (ML) samples obtained after hemorrhagic shock contain lipid mediators, such as lysophosphatidylcholine and arachidonic acid (AA), which induce the systemic inflammatory response to injury. We have previously demonstrated the ability of vagal nerve stimulation (VNS) to prevent gut barrier failure after injury. We hypothesized that VNS would regulate the biological activity of ML and the production of AA in the ML after intestinal ischemia reperfusion (IR) injury.

**Methods:** Male Sprague Dawley rats underwent cannulation of the mesenteric lymph duct. Animals were then subjected to 60 minutes of superior mesenteric artery (SMA) clamping followed by 120 minutes of de-clamping to induce gut IR injury. ML was collected before IR and during each hour after IR for to 2 hours. A separate cohort of animals underwent electrical cervical VNS (5V, 0.5 Hz, 1 ms, 10 min) after intestinal ischemia. Sham animals underwent an identical procedure but without SMA clamping. The biological activity of ML in each phase was measured based on the monocyte NF- $\kappa$ B activation. The lipids in ML were extracted using the method of Bligh and Dyer and liquid chromatography electrospray ionization mass spectrometry.

**Results:** The NF- $\kappa$ B activation of the ML of the IR group was significantly increased ( $p < 0.05$ ). VNS significantly limited the IR-induced increase in NF- $\kappa$ B activation in comparison to that in the IR group ( $p < 0.05$ ). A lipid analysis of ML showed that AA was significantly increased in the ML of IR groups in comparison to the sham and IR+VNS groups ( $p < 0.05$ ). Performing VNS after intestinal ischemia prevented the IR-induced increase in AA in ML ( $p < 0.05$ ).

**Conclusions:** VNS altered the biological activity in the ML and prevented the IR-induced increase in AA in the ML. Vagus nerve stimulation may attenuate the systemic inflammation that occurs after intestinal IR by altering the production of AA in ML.



## ENTERO-HEPATIC AXIS INJURY FOLLOWING HEMORRHAGIC SHOCK: A ROLE FOR URIC ACID.

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**Introduction:** Organ failure following hemorrhagic shock (HS) is responsible for late morbidity among trauma patients. Uric acid (UA), released from direct tissue damage and ischemia-reperfusion injury, activates the inflammatory cascade through the TLR-4/NLRP-3 signaling pathway and enhances ICAM-1 expression in vascular endothelium. We recently demonstrated an active role for UA in lung and kidney secondary injury following HS (1). We hypothesized that UA could also contribute to entero-hepatic injury following HS.

**Methods:** Male Wistar rats were randomly assigned to three groups following general anesthesia and femoral vessels cannulation: 1) Sham with cannulation alone; 2) HS (MAP target of 30 mmHg for 1h) with RL-blood resuscitation alone (HS); 3) HS with RL-blood + Rasburicase (1.5 mg/kg) resuscitation (HS+R). Rats were monitored and sacrificed 72 hours after HS. UA levels were measured in plasma and liver tissue using an assay (Cell-Biolabs). Liver injury was assessed using caspase 3/8 activity (enzymatic assay), TUNEL coloration and ICAM-1 expression (western blot). Intestinal injury was assessed using *ex-vivo* epithelial resistance measurement and intestinal cells (HT-29 cells) expression of junctional proteins (Zonula-occludin 1, E-cadherin, Claudin-4) following UA exposure. One-way ANOVA with Bonferroni or Games-Howell post-hoc analyses were performed depending on variance homogeneity.

**Results:** The addition of Rasburicase to resuscitation prevented HS-mediated elevation in plasma UA levels (Sham vs HS vs HS + R: 1.9 $\mu$ M vs 10.2 $\mu$ M\* vs 3.7 $\mu$ M\*\*). Despite no difference in liver UA levels between groups, the addition of Rasburicase to resuscitation prevented liver apoptosis after HS (Caspase 3 activity, sham as reference: 100% vs 178%\* vs 85%\*\*; Caspase 8: 100% vs 164%\* vs 111%\*\*; TUNEL, % of apoptotic cells: 3.1% vs 19.5%\* vs 2.9%\*\*). Increased ICAM-1 expression after HS was also prevented by Rasburicase (100% vs 178%\* vs 110%\*\*). With respect to small bowel injury, *ex-vivo* intestinal resistance was decreased in the HS group compared to sham; the intervention on UA *in vivo* prevented this phenomenon (114 $\Omega$  vs 82 $\Omega$ \* vs 112 $\Omega$ \*\*). Intestinal cells (HT29) exposed to UA *in vitro* showed decreased junctional protein expression (Zonula-occludin 1: 100% vs 64%#; E-Cadherin: 100% vs 70%#; Claudin-4: 100% vs 78%#).

**Conclusion:** After resuscitated HS, UA is involved in liver injury. HS-induced increased small bowel permeability through decreased adhesion proteins could be an indirect mechanism that is UA-mediated. Further investigation is needed to better understand this mechanism and ultimately target UA in patients with traumatic HS.

\*HS vs Sham,  $p < 0.05$ ; \*\*HS vs HS + R,  $p < 0.05$ ; #Control vs AU 10<sup>-4</sup> nM,  $p < 0.05$

(1) K. Gilbert et al, Journal of Trauma and Acute Care Surgery, 2019

## **SHIFT IN NEUTROPHIL PHENOTYPES DETECTED BY 24/7 ANALYSIS IN THE SHOCKROOM: A NEW BIOMARKER ASSOCIATED WITH TISSUE DAMAGE.**

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### **Introduction:**

Traumapatienten are at risk for severe infections after trauma. The risk for these infections is associated with the severity of tissue damage and the amplitude of the following immune response. Injury Severity Score (ISS) and New Injury Severity Score (NISS) only grossly score the cumulative amount of tissue damage. Moreover, they do not correlate with the individual immune response of trauma patients. Neutrophils act as important cells in the common final pathway of the immune response after trauma. Previous studies showed that shifts in neutrophil phenotypes are promising in the prediction of inflammatory complications. However, technical and logistical difficulties preclude application of such test in the clinical setting. Now, these can be circumvented by application of a fully automated point-of-care flow cytometry system. The aim of this study was to find biomarkers that correlates with the amplitude of the immune response after trauma.

### **Methods:**

A prospective mono-center cohort study was performed in our level one trauma center from November 2018 until February 2019. All trauma patients >18y initially presented at the shock room were included by the trauma team. An extra tube of blood was obtained during standard diagnostic workup and was placed in the 24/7 available load-and-go flowcytometer, AQUIOS CL, co-located in the shock room. This machine measured the blood samples automatically within 20 minutes after sampling. The markers FcγRIII (CD16) and L-selectin (CD62L) were used to identify different neutrophil phenotypes. All patient characteristics and follow-up data were collected from the electronic medical record.

### **Results:**

Data was analyzed in 159 patients. A total of 38 patients had an ISS  $\geq 16$ . Traumapatienten with an ISS <16 showed a significant higher percentage of CD16dim neutrophils (range 0 - 4.1%), compared to healthy controls (mean (SD)  $0.9 \pm 0.8$  vs.  $0.2 \pm 0.1$ ,  $P=0.001$ ). Poly trauma patients had a significant higher percentage of CD16dim neutrophils (range 0.1-21.1%) compared to traumapatienten with an ISS <16 ( $5.7 \pm 5.6$  vs.  $0.9 \pm 0.8$ ,  $P<0.001$ ). All patients with an ISS  $\geq 24$  have more than 5% CD16dim neutrophils.

### **Conclusion:**

The percentage of CD16dim neutrophils appears to be associated with the amount of tissue damage. This quick 24/7 applicable bedside analysis of CD16dim neutrophils used as read out for tissue damage might proof a valuable tool for clinical decision making in trauma surgery.

## EXTRACORPOREAL MEMBRANE OXYGENATION USE IN TRAUMA: TEMPORAL TRENDS AND FUTURE DIRECTIONS

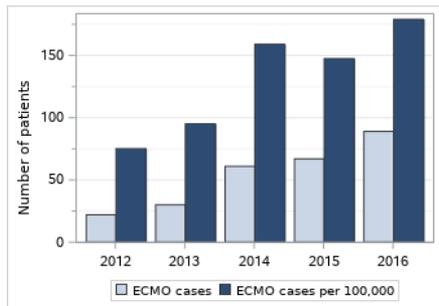
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**Introduction:** While early studies of extracorporeal membrane oxygenation (ECMO) reported poor outcomes, greater clinical experience and the decreased need for systemic anticoagulation on modern circuits has renewed interest in the use of ECMO for post-traumatic respiratory and cardiopulmonary failure. The objectives of this study were to characterize contemporary patterns of ECMO utilization at trauma centers across North America and to describe the outcomes of trauma patients undergoing ECMO.

**Methods:** Data were derived from the American College of Surgeons Trauma Quality Improvement Program (TQIP) dataset. We included adults with at least one severe injury (Abbreviated Injury Scale  $\geq 3$ ) admitted to a level I or II trauma center between 2012 and 2016 who received at least one day of mechanical ventilation. Patients were categorized based on whether or not they received ECMO during their admission. The primary outcome of interest was the change in the incidence of ECMO across study years. An annual average growth rate, standardized to the size of the cohort in a given year was calculated, representing the geometric mean of the growth rate over the entire study period. Furthermore, we evaluated variation in ECMO volumes across centers and unadjusted patient outcomes.

**Results:** Out of 194,314 severely injured patients requiring mechanical ventilation across 450 centers, 269 (0.14%) received ECMO. Patients who received ECMO were younger and had fewer comorbidities than those who did not receive ECMO. Patients with severe head injuries were underrepresented in the ECMO group, whereas patients with severe torso injuries were overrepresented. ECMO patients had a significantly higher mortality rate than non-ECMO patients (32% vs. 19%). The standardized rate of ECMO increased significantly from 2012 to 2016, growing from 75.2 to 179.0 ECMO cases per 100,000 severely injured patients requiring mechanical ventilation. The average annual growth rate was 24% ( $p=0.02$ ). Of the 82 (18%) centers reporting at least 1 ECMO case, the median number of cases over the study period was 2. Thirty-four (41%) ECMO centers reported only a single case, and only 5 centers reported more than 10 cases.

**Conclusions:** The use of ECMO for trauma, although rare, is rapidly increasing in frequency. Moreover, approximately two thirds of patients who receive ECMO following traumatic injury survive their hospitalization. Taken together, these data suggest that ECMO may represent a potential treatment strategy for trauma patients with respiratory or cardiopulmonary failure. However, given the rarity of the procedure, there exists an opportunity to develop practice guidelines regarding the indications for, and approach to, ECMO in the setting of trauma.



**CIRCULATING MITOCHONDRIAL DNA IS ASSOCIATED WITH FIBRINOLYTIC SHUTDOWN AFTER INJURY**

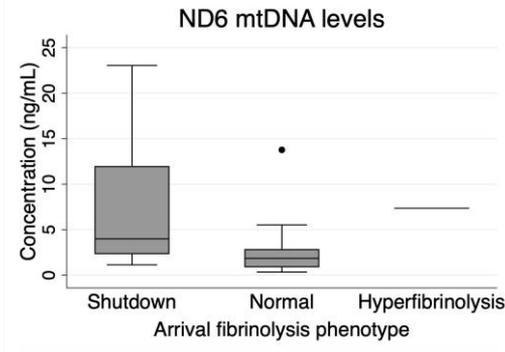
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**Introduction:** Mitochondrial DNA (mtDNA) is a damage-associated molecular pattern released in response to trauma, and is correlated with later acute lung injury and multiorgan failure. We aimed to identify associations between elevated mtDNA levels and coagulation abnormalities after severe injury.

**Methods:** Critically injured patients meeting highest-level trauma activation criteria were prospectively enrolled under waiver of consent, and blood sampled within 6h of arrival. Real-time quantitative PCR for the ND6 mitochondrial DNA sequence was performed. Citrated kaolin thromboelastography (TEG) was performed. Fibrinolytic phenotype was divided into shutdown, normal, and hyperfibrinolytic ranges based on Lysis Index at 30min (LY30).

**Results:** Blood samples were obtained from 35 injured patients (22 males and 16 females) with mean injury severity score 15. Traumatic brain injury (median 7.8 vs. 2.3ng/mL,  $p=0.045$ ) and prehospital transfusion (median 21.5 vs. 2.3ng/mL,  $p=0.048$ ) were associated with elevated levels of mtDNA. With the exception of TEG-LY30, TEG parameters and standard laboratory coagulation assays did not correlate with mtDNA levels. In terms of fibrinolytic phenotype, 29% of injured patients demonstrated fibrinolytic shutdown, 68% had normal-range fibrinolysis, and 3% had hyperfibrinolysis. Median mtDNA concentration was 4.0ng/mL (interquartile range 2.3 – 12.0) in patients with shutdown, compared to 1.9 (1.1 – 2.9) in those with normal or hyperfibrinolysis (Kruskal-Wallis  $p=0.033$ ; see figure). When adjusted for age and injury severity, mtDNA level remained a significant predictor of admission fibrinolytic shutdown (odds ratio 1.18,  $p=0.024$ , model area under the curve 0.762).

**Conclusion:** Circulating mtDNA is specifically associated with traumatic brain injury, transfusion, and early fibrinolytic shutdown. In addition to its known proinflammatory signaling, mitochondrial DNA may modulate fibrinolysis, leading to microvascular thrombosis and multiple organ failure after severe injury.



## IMPACT OF SERIOUS MENTAL ILLNESS ON OPIOID MEDICATION USE AND OUTCOMES IN PATIENTS ADMITTED TO A LEVEL 1 TRAUMA CENTER

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**Introduction:** The incidence of serious mental illness in trauma patients is not well described. However, previous studies suggest that patients with serious mental illness have an increased risk of mortality and morbidity compared to the general population. The aims of this study are to describe the incidence of serious mental illness in trauma patients, their outcomes, and their opioid, antipsychotic, and sedative medication requirements compared to patients without serious mental illness.

**Methods:** Following IRB approval, all patients entered in the Trauma Registry from 1/1/2016-12/31/2017 were identified. Patients 18 years or older and who were admitted to the trauma service were included. Patients who were pregnant, incarcerated, admitted to other services, or direct transfers that bypassed the emergency room were excluded. Two groups were created: SMI for patients with a documented history of major depressive disorder, bipolar disorder, schizophrenia, or anxiety, or admission due to self-injury, and Non-SMI. Univariate analysis was performed using Wilcoxon rank sum, Chi-square, and Fisher's Exact test, and are reported as medians with 25th/75th inter-quartile range and means with standard deviation, where appropriate. A purposeful logistic regression model was created to assess mortality as well as medication requirements. All analyses were performed using STATA 12.1.

**Results:** Over the study period 3,708 patients met inclusion criteria, of which 390 (11%), were in the SMI group. No differences were found in age, ISS, arrival GCS, or rates of traumatic brain injury. The SMI patients were more likely to be women (45% vs. 27%,  $p < 0.001$ ), white (62% versus 40%,  $p < 0.001$ ), and to sustain penetrating injury (24% vs. 16%,  $p = 0.001$ ). The SMI group also had fewer hospital-free days [24 (16, 27) vs. 25 (20, 28)], and required more doses of sedatives [5 ( $\pm 16$ ) vs. 2 ( $\pm 7$ )] and antipsychotics [7 ( $\pm 29$ ) vs. 2 ( $\pm 10$ )], all  $p < 0.001$ . There were no significant differences in mortality, morbidity, or morphine milligram equivalents (MME) per day. However, when controlling for age, ISS, and male gender, SMI group status was associated with a reduction in mortality and an increase in daily MME (Table 1), sedatives (OR 1.7, 95% C.I. 1.37-2.16), and antipsychotics (OR 4.1, 95% C.I. 3.14-5.34).

**Conclusion:** Serious mental illness is three times more common among patients admitted for trauma when compared to the 12-month prevalence of 4% in the United States general population. Although trauma patients with serious mental illness had similar injury severity and lower mortality, their increased utilization of resources, and sedative and opioid medications highlight potential areas for improvement in their care.

<i>In-hospital Mortality</i>			
	Odds Ratio	95% C.I.	p-value
SMI group status	0.34	0.16-0.70	0.004
Age	1.03	1.02-1.04	<0.001
ISS	1.13	1.11-1.14	<0.001
Male gender	1.02	0.72-1.45	0.905
<i>Morphine Milliequivalents/day</i>			
	Odds Ratio	95% C.I.	p-value
SMI group status	2.54	1.10-5.87	0.028
Age	0.98	0.97-0.99	<0.001
ISS	0.96	0.95-0.97	<0.001
Male gender	1.30	0.89-1.89	0.166

Table 1.

## VASOPRESSOR CHOICE DURING CRITICAL CARE MANAGEMENT OF BRAIN DEAD ORGAN DONORS AND THE EFFECTS ON KIDNEY GRAFT FUNCTION

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**Introduction:** Delayed graft function (DGF), the need for dialysis in the first week following kidney transplant, affects one-quarter of deceased-donor recipients. DGF is associated with increased resource utilization and risk of adverse transplant outcomes, including acute rejection, chronic allograft nephropathy, and graft loss. Donor demographics and serum creatinine, as well as graft cold ischemia time, have been previously associated with DGF. However, there have been limited studies examining the impact of donor critical care parameters and treatments on the development of DGF in the recipient. There is also no consensus on the optimal vasopressor to support the hemodynamic instability that follows brain death. Therefore, our objective was to determine the relationship between vasopressor usage during donor management and the development of DGF.

**Methods:** Prospective observational data were collected for all organ donors after brain death (DBDs) managed by 17 Organ Procurement Organizations (OPOs) from 9 UNOS Regions between 2012 and 2018. Donor critical care parameters, including vasopressor doses, were recorded at three time points during donor management: (1) after authorization for donation, when the OPO assumes responsibility for care of the donor, (2) at the time of organ allocation, and (3) at the conclusion of donor management, just prior to organ recovery. Deidentified recipient outcome data were linked with the donor data via the UNOS donor identification numbers. Only donors who received at least one vasopressor at all three time points were included in the analysis. The primary outcome measure was DGF. To compare the relative impact of each vasopressor on the occurrence of DGF, vasopressor doses were converted to norepinephrine equivalent doses and analyzed as continuous variables. Univariate analyses were conducted to determine the association between donor variables and DGF. Results were adjusted for known predictors of DGF using binary logistic regression to determine independent predictors with  $p < 0.05$ .

**Results:** During the study period, complete data were available for 5,554 transplanted kidneys from 2,985 DBDs. The mean (SD) donor age was 40.6 (14.1) years, kidney donor profile index (KDPI) was 46.0 (27.8), and serum creatinine prior to organ recovery was 1.4 (1.1) mg/dL. Of the kidney transplant recipients, 27.1% developed DGF. On univariate analysis, age, cold ischemia time, donor subtype, kidney donor profile index, serum creatinine, phenylephrine dose, and dopamine dose were associated with DGF. After multivariate analysis, increased age, cold ischemia time, kidney donor profile index, serum creatinine, and phenylephrine dose remained independent predictors of DGF.

**Conclusion:** Compared with other vasopressors, higher doses of phenylephrine in the DBD were an independent predictor of DGF in the recipient. Except for phenylephrine, vasopressor usage during donor management did not predict the development of DGF in kidney transplant recipients.

## **HOLD OFF ON THAT ANTIFUNGAL! POSITIVE FUNGAL CULTURES IN THE PERITONEUM FROM PERFORATED PEPTIC ULCERS DO NOT INCREASE THE RISK OF ORGAN SPACE INFECTION**

Galinos Barmparas MD, Adel A. Saleh MD, MRCS, Sharmila Dissanaiké\* MD, Brandon R. Bruns\* MD, Alexander R. Raines MD, Elizabeth B. Scherer MD, MPH, Thomas J. Schroepel MD, MS, Richard C. Frazee MD, Eric M. Champion MD, Jeremy Ward MD, Daniel R. Margulies\* MD, Cedars-Sinai Medical Center And The SWSC MCT Group

**Introduction:** The association between fungal isolates in peritoneal cultures of perforated peptic ulcer (PPU) patients with subsequent organ space infection (OSI) is unknown. The hypothesis of this study was that fungal isolates do not increase the risk of OSI and empiric administration of antifungals does not decrease this risk.

**Methods:** A secondary analysis of a multicenter study of patients treated for PPU at 9 institutions, between 2011 & 2018, was conducted. Patients with fungal isolates were compared to those without and patients receiving antifungals perioperatively were compared to those who did not. The primary outcome was OSI. Cohorts were compared using  $\chi^2$  test.

**Results:** 633 patients were reviewed with 53% receiving an antifungal agent perioperatively for a median of 4 days. Intraoperative cultures were obtained from 126 patients (20%), comprising the study cohort. The median age and Charlson Comorbidity Index were 60 years and 4 respectively. The most commonly isolated microorganism was *Candida* (48%), followed by *Streptococci* (21%). Patients with *Candida* (n=60/126) had a lower incidence of OSI (17% vs. 27%; OR: 0.53; p=0.15). Patients who received antifungals (n=92/124) had a higher incidence of OSI (24% vs. 16%; OR: 1.70; p=0.33), including those who had *Candida* in their intraoperative cultures (17% vs. 9%; OR: 2.05; p>0.99).

**Conclusion:** The presence of fungi in intraoperative cultures of patients undergoing surgery for PPU was not associated with an increased risk for OSI; administration of antifungals had no impact on this risk. Routine use of antifungals in this setting may be unnecessary.

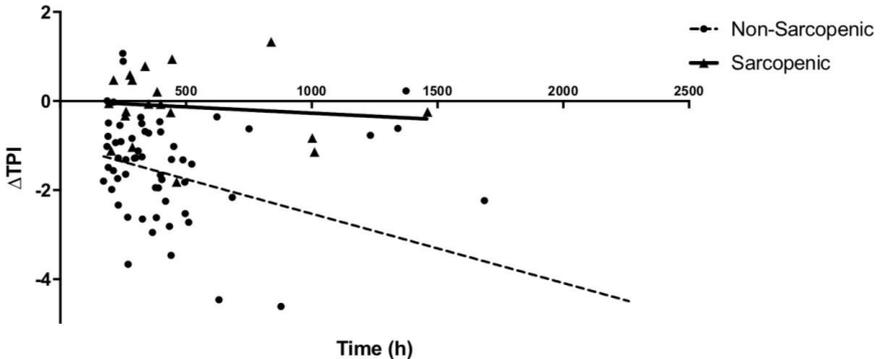
## THE MORE YOU HAVE-THE MORE YOU LOSE: MUSCLE MASS DETERIORATION IN SEVERELY INJURED TRAUMA PATIENTS

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**Introduction:** Sarcopenia is a clinically relevant loss of muscle mass and function that can be objectively quantified with CT imaging. It has implications of increased morbidity and mortality in adult trauma populations and poor surgical outcomes. Our study aimed to evaluate loss of muscle mass change in adult trauma patients with prolonged hospital stays.

**Methods:** A retrospective analysis was performed using our trauma registry to identify all adult trauma patients admitted to our urban, academic Level 1 Trauma center between 2010 and 2017. Inclusion criteria were patients with a hospital length of stay greater than 14 days. All CT images were reviewed, and the cross-sectional area ( $\text{cm}^2$ ) of the left psoas muscle was measured for each patient at the level of the third lumbar vertebral body to determine total psoas area (TPA). The TPA was then normalized for patient stature by dividing by patient height squared ( $\text{m}^2$ ) to determine the Total Psoas Index (TPI). Sarcopenia was defined as a TPI on admission below gender specific thresholds of  $5.45 \text{ (cm}^2/\text{m}^2)$  in men and  $3.85 \text{ (cm}^2/\text{m}^2)$  in women. The TPA, TPI, and rates of change in TPI were then evaluated and compared between sarcopenic and non-sarcopenic adult trauma patients.

**Results:** There were 81 adult trauma patients who met inclusion criteria. Patients were on average 43 years old, 70% male, 64% Caucasian, 90% sustained blunt trauma, and had an ISS=29. The average change in TPA was  $-3.8 \text{ cm}^2$  and TPI was  $-1.3 \text{ cm}^2$ . On admission, 23% ( $n=19$ ) of patients were sarcopenic while 77% ( $n=62$ ) were not. The two groups were similar for demographics and injury severity, but sarcopenic patients were older (59 vs. 39,  $p<0.0001$ ). Non-sarcopenic patients had a significantly greater change in TPA ( $-4.9$  vs.  $-0.31$ ,  $p<0.0001$ ) and TPI ( $-1.7$  vs.  $-0.13$ ,  $p<0.0001$ ). In addition, 37% of patients who were admitted with normal muscle mass subsequently developed sarcopenia during hospital admission. Older age was the only risk factor independently associated with developing sarcopenia while hospitalized (OR: 1.04, 95% CI 1.00-1.08,  $p=0.045$ ). Furthermore, the rate of decrease in muscle mass was significantly greater ( $p=0.0002$ ) for non-sarcopenic patients during their hospital stay (Figure 1, non-sarcopenic patients shown as dotted line).



**Conclusion:** Adult trauma patients lose significant muscle mass during prolonged hospitalization. Over a third of patients with normal muscle mass at admission subsequently develop sarcopenia and older age is the primary risk factor to develop sarcopenia while hospitalized. Patients with normal muscle mass (non-sarcopenic) at admission have greater decreases in TPA and TPI and have a significantly accelerated rate of muscle mass loss when compared to sarcopenic patients.

## **A SURGICAL CRITICAL CARE LED PROGRAM INCREASES VOLUME AND IMPROVES OUTCOMES IN EXTRACORPOREAL CARDIOPULMONARY RESUSCITATION**

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**Introduction:** Extracorporeal life support (ECLS) has emerged as a potentially life saving adjuvant to conventional ACLS. Cardiopulmonary resuscitation (CPR) is associated with poor survival with a 8-19% survival rate for out-of-hospital cardiac arrest with conventional CPR. The acute care surgery (ACS) and surgical critical care (SCC) model provides a unique opportunity for timely cannulation in this highly critical subset of patients. Starting in 2018, the ACS and SCC service assumed leadership of the extracorporeal CPR (E-CPR) program at our institution.

**Methods:** We performed a retrospective review of patients at our urban tertiary hospital that underwent E-CPR. We utilized our internal database to evaluate our experience from 2012 to 2017 and then compared that to 2018 which represents the transition of leadership of the E-CPR program.

**Results:** From 2012 to 2017, 25 patients were treated with E-CPR. All were peripherally cannulated by the cardiothoracic surgery team. Twelve (48%) were weaned from ECLS with 7 (28%) surviving to discharge. In 2018, 22 patients were treated with E-CPR. Fourteen (64%) were weaned from ECLS with 11 (50%) surviving to discharge. Cannulation and initiation of ECLS was performed in the ED following out of hospital arrest in 11 of the 22 patients. The SCC service performed 9 (81.8%) of these ED cannulations and the remaining 2 were done in combination with CTS. Survival from ED cannulation was 63.6% (7/11). Of the eleven patients who survived E-CPR, 9 had normal neurologic recovery with the remaining two returning to baseline status. Two patients (9%) had limb ischemia requiring amputation, one performed by SCC alone and one in combination with CTS.

**Conclusion:** An acute care surgery and surgical critical care team can increase access to ECLS and can improve outcomes in those with out-of-hospital cardiac arrest.

**ECMO IN TRAUMA: DO TRAUMA CENTER LEVEL AND ECMO VOLUME IMPACT OUTCOMES?**

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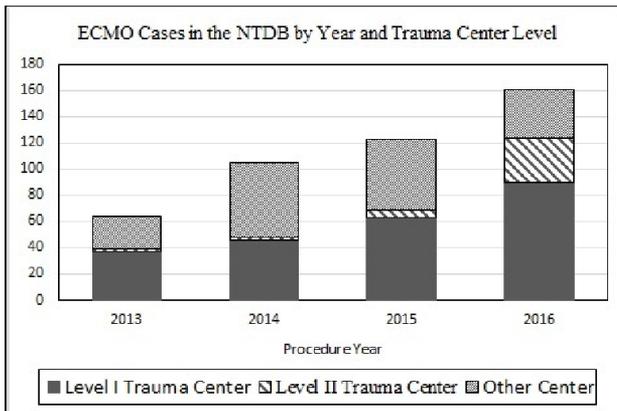
**Introduction:** The use of extracorporeal membrane oxygenation (ECMO) for injured patients nationwide is unknown. We sought to examine ECMO use and patient outcomes using a large national database. We hypothesized that trauma center American College of Surgeons (ACS) verification level, ECMO volume, and patient injury severity are associated with the rate of mortality for ECMO in trauma patients.

**Methods:** Adult patients who received ECMO from 2013 to 2016 were identified in the National Trauma Data Bank. Patient demographic and injury data were analyzed in addition to ACS verification level and ECMO volume for trauma patients during the study interval. Associations between patient, procedural, and institutional factors with mortality were assessed using multivariable logistic regression modeling.

**Results:** 448 patients were included in the analysis. ECMO use increased at Level I and Level II trauma centers each year (**Fig. 1**). Overall, survival after ECMO for trauma was 62% (58% at Level I, 82% at Level II, and 63% at other centers;  $p=0.016$ ). Although survival was higher at Level II versus Level I centers ( $p=0.001$ ), patients at Level II centers were significantly less injured than those at Level I centers (median ISS 11 vs. 26,  $p=0.017$ ). Centers with less than 9 ECMO trauma patients had a two times higher mortality rate ( $p=0.017$ ).

**Conclusions:** ECMO increased at Level I and Level II trauma centers. Survival was higher at centers that did at least 9 trauma ECMO procedures. Level II centers also had improved survival although their patients were less severely injured. Further study is warranted to clarify which trauma patients benefit from ECMO and to develop guidelines that ensure ECMO is reserved for patients who fail conventional management strategies.

**Figure 1:** National ECMO use for trauma by year and trauma center level.



**REAL-TIME VITAL SIGNS PREDICT ORGAN FAILURE ASSESSMENT (SOFA) SCORE IN TRAUMA PATIENTS**

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**Objectives:** The Sequential Organ Failure Assessment (SOFA) at 24 hours is associated with a greater risk of death or prolonged intensive care unit (ICU) stay. The aim of this study is to determine whether autonomous continuous vital sign monitoring can predict SOFA scores in critically injured patients.

**Methods:** Included adult trauma patients with an Injury Severity Score (ISS)  $\geq 16$  over a 3-year period admitted to the ICU. Continuous vital sign data was used in a boosting tree model to predict the SOFA score from admission until 24 hours. Bland Altman plot assessed the difference between the model predicted and calculated SOFA score.

**Results:** 500 patients met the inclusion criteria. Mean age was 43 standard deviation (SD)  $\pm 20$  years, 74 % were male. 69% sustained blunt injury. 36% of patients had an Abbreviated Injury Scale (AIS) for body region head  $\geq 3$ . Of the traumatic brain injury patients, the mean motor Glasgow Coma Scale (GCS) at admission was 4. In the overall cohort mortality was 13% and the median length of ICU stay was 13.5 days. The continuous vital sign model predicted the SOFA score within 1, 2, 3, 4, and 5 points by 41%, 62%, 78%, 86% and 93% respectively. Bland Altman showed a bias of 0.06 and 95% confidence interval (CI) of  $\pm 6$  (Figure 1).

**Conclusion:** An objective method implemented at the bedside to identify patients at risk of morbidity and mortality and increased length of ICU stay is possible through automated continuous capture of physiological data without provider input.

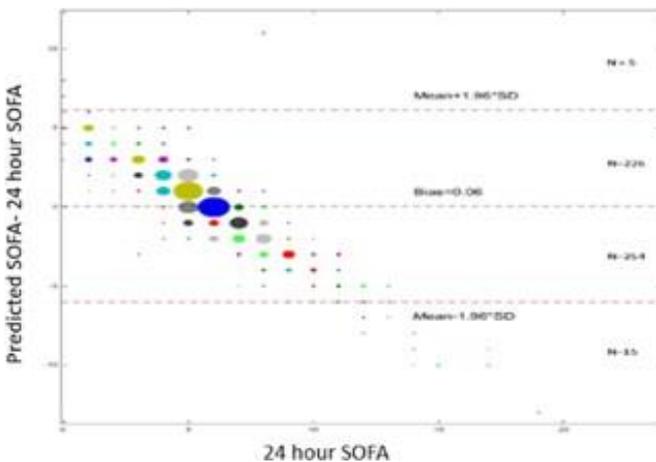


Figure 1 (left): Bland Altman plot between calculated 24h and predicted SOFA score.

**DEFINING RISK AND RISK FACTORS FOR ICU READMISISON OF TRAUMA PATIENTS: DEVELOPING A PREDICTIVE RISK SCORE**

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**Introduction:** Multiple studies demonstrate that ICU readmissions or ‘bouncebacks’ (ICUbb) are associated with worse clinical outcomes. However, there is a paucity of data defining the risk and factors associated with ICUbb. The current study aims at closing this gap in knowledge and developing a predictive risk score for ICUbb. We hypothesize that specific patient characteristics and injury patterns are associated with ICUbb.

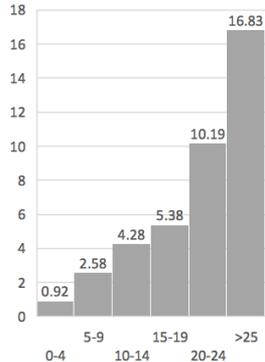
**Methods:** Trauma patients admitted to ICU at a level-1 trauma center over a 10-year period ending April 2018 were identified. Patient characteristics [age, Charlson Comorbidity Index (CCI)] and body-region injury severity (AIS scores) were analyzed. Patients with and without ICUbb were compared using multivariate logistic regression. Predictive risk score for ICUbb was developed by assigning weighted values to independent variables using log-risk coefficients.

Characteristic	OR (95% CI)
Age (per 10yrs)	1.36 (1.23-1.52)
CCI (per 5pts)	1.49 (1.08-2.06)
Thorax AIS≥3	1.85 (1.26-2.72)
Spine AIS≥3	2.20 (1.31-3.69)
Low Extr. AIS≥3	2.13 (1.40-3.24)
Burns AIS≥3	4.52 (1.54-13.27)

**Results:** 3,500 patients met criteria of which 134 (3.98%) experienced ICUbb. Age, CCI, and severe injuries (AIS>=3) to chest, spine, lower extremities, and burns were identified as independent risk factors for ICUbb (Table 1). The ICUbb risk score was developed using age, CCI, and severe injury to chest, spine, lower extremities and burns. Increasing risk score was associated with higher rates of ICUbb (Figure 1) with AUROC of 0.712.

**Conclusion:** Increasing age, higher CCI, and severe injuries to chest, spine, lower extremities, and burns are associated with ICUbb. A score <15 has low risk of ICUbb and safe for ICU transfer out, while score > 20 has high risk and may warrant additional ICU care.

**Figure 1:** Percent of Patients with ICUbb by Risk Score



## CONSEQUENCES OF DELAYED INTER-HOSPITAL TRANSFER OF CRITICALLY ILL PATIENTS WITH SURGICAL SEPSIS

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**Introduction:** Suboptimal triage of critically ill patients with surgical sepsis may contribute to adverse outcomes. Patients transferred to a tertiary care center after spending  $\geq 24$  hours at an outside facility were compared with patients who had early triage to a tertiary care center with the null hypothesis that management parameters and outcomes would be similar between groups.

**Methods:** This prospective observational cohort study included 308 critically ill septic patients treated at a tertiary care center. Patients transferred after spending more than 24 hours at an outside facility (n=69) were compared with patients who were directly admitted or transferred within 24 hours (n=239). Patient characteristics, management parameters, and outcomes were compared between groups.

**Results:** Average outside facility length of stay in the delayed transfer (DT) group was 43 hours. DT patients had higher SOFA (7.5 vs. 5.8,  $p=0.004$ ) and APACHE II scores (20.2 vs. 17.2,  $p=0.007$ ) at admission. The interval between admission and source control was significantly longer in the DT group (5.9 vs. 0.9 hours,  $p=0.009$ ). The incidence of secondary infection was significantly higher in the DT group (41% vs. 23%,  $p=0.005$ ). DT was independently associated with a 10-day increase in hospital length of stay. In-hospital mortality was two-fold higher in the DT group (14.5% vs. 7.1%,  $p=0.056$ ). DT patients were less likely to be discharged home (22% vs. 59%,  $p<0.001$ ).

**Conclusion:** Septic patients who spent more than 24 hours at an outside facility prior to transfer had greater initial illness severity, longer intervals between admission and source control, more nosocomial infections, and were less likely to be discharged home compared with patients who had early triage to a tertiary care center.

IMPACT OF DEPRIVATION AND COMORBIDITY ON OUTCOMES IN EMERGENCY GENERAL SURGERY

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**Introduction:** Health inequalities exist between the most deprived and most affluent populations. However, whether socio-economic deprivation or comorbidities affects the outcome of Emergency General Surgery (EGS) admissions is unknown. The aim of this study was to examine the impact of deprivation and comorbidity on mortality, discharge destination and length of hospital stay in EGS patients in Scotland.

**Methods:** Prospectively collected data from all Scottish EGS admissions between 1997 and 2016, involving adults (aged >15), were obtained from the Scottish Government. Data included age, gender, Scottish Index of Multiple Deprivation (SIMD) deciles (1=most deprived; 10= least deprived), 5-year Charlson Comorbidity Index (CCI), and outcomes including mortality, discharge destination, and length of hospital stay (LOS). Binomial regression was used for mortality and discharge destination, while Poisson regression was used for LOS.

**Results:** 1,586,461 EGS admissions were identified. 253,392 (16.0%) were in SIMD decile 1, and 87,531 (5.5%) in SIMD decile 10. 1,209,854 (76.3%) have CCI=0, 351,926 (22.2%) have CCI 1-4, and 24,681 (1.6%) have CCI >4. 1,254,627 (79.1%) were discharged home, while 331,834 (20.9%) were not discharged home. 1,559,612 (98.3%) were discharged and 26,849 (1.7%) died. A heat table demonstrates that as deprivation and comorbidity increase, mortality increases. Regression analyses showed that, compared with those with CCI>8, patients with CCI=0 had lower mortality (incidence risk ratio (IRR) 0.072; 95% confidence interval (CI) 0.061-0.084), were more likely to be discharged home (IRR 2.686; 95% CI 2.429-2.970), and had shorter LOS (IRR 0.647; 95% CI 0.634-0.659).

Compared to those living in SIMD decile 10 (least deprived), patients living in SIMD decile 1 (most deprived) had higher mortality (IRR 1.379; 95% CI 1.294-1.470), were less likely to be discharged home (IRR 0.959; 95% CI 0.941-0.979), and higher LOS (IRR 1.103; 95% CI 1.098-1.107). All p values <0.001.

**Conclusion:** Increased levels of socio-economic deprivation and comorbidity significantly affects EGS outcomes including mortality, discharge destination, and length of hospital stay.

Mortality Rate	Charlson Comorbidity Index (5 Year)									
	0	1	2	3	4	5	6	7	8	>8
SIMD 1	0.005	0.026	0.063	0.064	0.044	0.043	0.188	0.166	0.123	0.126
2	0.006	0.032	0.067	0.076	0.047	0.056	0.157	0.197	0.132	0.104
3	0.006	0.035	0.060	0.073	0.059	0.046	0.176	0.177	0.135	0.166
4	0.007	0.035	0.057	0.074	0.041	0.041	0.168	0.248	0.147	0.090
5	0.006	0.042	0.055	0.069	0.043	0.056	0.161	0.189	0.107	0.128
6	0.007	0.037	0.054	0.062	0.052	0.086	0.149	0.170	0.096	0.150
7	0.007	0.042	0.054	0.071	0.053	0.052	0.127	0.176	0.100	0.107
8	0.007	0.037	0.056	0.060	0.045	0.012	0.138	0.118	0.107	0.139
9	0.006	0.038	0.053	0.056	0.037	0.090	0.119	0.155	0.110	0.103
10	0.006	0.043	0.051	0.071	0.043	0.042	0.131	0.200	0.090	0.099

## VALIDATION OF THE AAST GRADING SYSTEM FOR ACUTE APPENDICITIS SEVERITY

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**Introduction:** The American Association for the Surgery of Trauma (AAST) developed and published an anatomic grading system in 2014 to assess disease severity in emergent general surgery conditions. This grading system allows for assessment of the progression of disease severity through various grades of inflammation based upon clinical, imaging, operative, and pathology characteristics. Assignment of a grade could then be utilized in risk-adjustment and stratification of patient outcomes for clinical benchmarking. Our objective was to validate the AAST grading system for acute appendicitis by examining the association of AAST grade with clinical outcomes.

**Methods:** Surgical quality program data was abstracted and prospectively collected on all adult patients with the diagnosis of acute appendicitis treated at an academic medical center between 12/2013 and 5/2018. An AAST acute appendicitis grade from 1 to 5 was assigned by a clinical nurse reviewer for all patients who underwent open or laparoscopic appendectomy. Patients who did not undergo operative intervention were excluded from the analyses. Primary outcomes were occurrence of a major complication, any complications, and total length of stay for the index hospitalization. Multivariable models were constructed for each outcome without and with inclusion of the AAST grade as an ordinal variable. Other independent variables utilized in the risk-adjustment models were demographic information, insurance provider, surgical technique, and medical comorbidities.

**Results:** Our sample included 734 total patients who underwent appendectomy for acute appendicitis. The AAST score distribution included 561 (76%) in Grade 1, 49 (6.7%) in Grade 2, 79 (10.8%) in Grade 3, 33 (4.5%) in Grade 4, and 12 (1.6%) in Grade 5. The mean age was 35.3 (SD 14.7), 346 (47%) were female, 147 (20%) were non-white, and 506 (69%) had private insurance. Major complications, any complications, and length of stay were all positively associated with AAST grade (Table). Model fit improved after including AAST grade (for the major complications model, c-statistic increased from 0.81 to 0.89; for the any complications model, c-statistic increased from 0.68 to 0.76). AAST grade was significantly associated with length of stay among other covariates, and multivariable linear regression model fit was improved after including AAST grade ( $R^2=15.3\%$  vs  $20.9\%$ ).

Outcome	AAST Acute Appendicitis Severity Grade					p-value
	1 (n=561)	2 (n=49)	3 (n=79)	4 (n=33)	5 (n=12)	
Major Complication (n, %)	1 (0.2%)	2 (4.1%)	5 (6.3%)	0 (0%)	1 (8.3%)	<0.001
Any Complication (n, %)	13 (2.3%)	6 (12.2%)	13 (16.5%)	1 (3.0%)	2 (25.0%)	<0.001
Length of Stay (mean days, SD)	1.1 (0.9)	1.8 (2.6)	2.9 (2.9)	5.6 (11.4)	5.3 (3.4)	<0.001

**Conclusion:** Our results demonstrate that the progressive AAST grading system for acute appendicitis is a valid measure of disease severity. Increased AAST grade is associated with higher rates of complications and longer length of stay in patients with acute appendicitis. The AAST grading system should be implemented for data collection and clinical benchmarking in hospital systems. Future research should focus on validation of the AAST grades in other disease cohorts.

## ACGME CASE LOG DATA DO NOT ADEQUATELY DESCRIBE GENERAL SURGERY RESIDENT EXPERIENCE WITH EMERGENCY GENERAL SURGERY CASES

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**Introduction:** Emergency general surgery (EGS) cases are complex and often technically difficult as compared to the same operations in non-emergent settings. While graduating general surgery residents must document minimum case numbers in a variety of categories, there are few data describing general surgery resident experience with EGS procedures. Thus it is unclear whether residents obtain adequate experience in EGS. We hypothesize that EGS experience is variable and unable to be adequately assessed based on currently available data.

**Methods:** National ACGME case log data from graduating surgery residents from 2013-2018 were queried for resident experience in the most commonly performed laparoscopic and open EGS procedures (colectomy, small bowel resection, cholecystectomy, repair of gastric and duodenal perforation, lysis of adhesions, appendectomy, and laparotomy). Yearly means and maximums were recorded. The ACGME tracked codes report was evaluated for codes specific to emergency surgery. Trauma codes and cases not for major credit were excluded.

**Results:** National ACGME case logs revealed highly variable experience with common EGS procedures. Repair of duodenal perforation was the least commonly performed case; laparoscopic cholecystectomy was the most common. For 11 of 13 case types reviewed, elective and emergency cases could not be differentiated. Further review of all ACGME tracked codes revealed that, of over 3000 codes, only 275 nontrauma codes referred specifically to emergency cases.

**Conclusions:** Available case log data for general surgery residents reveal a variable experience with EGS procedures. A minority of non-trauma ACGME case log track codes are available to specify experience with emergency cases. In order to assure that graduating residents are adequately trained in this vital segment of general surgery, we suggest that an emergency designation be added to ACGME case logs to better quantify experience with complex EGS cases.

**2013-2018 ACGME case log numbers for common EGS procedures**

Case Description	Mean	Max
Open colectomy	33.76	96.6
Lap colectomy	29.66	116.8
Open enterectomy	16.96	60.8
Lap enterectomy	1.26	23.4
Open cholecystectomy	8.42	45.2
Lap cholecystectomy	112.38	295.4
Repair gastric perforation	2.44	15.2
Repair duodenal perforation	0.38	5.6
Open adhesiolysis	4.46	45
Lap adhesiolysis	6.24	56
Open appendectomy	7.36	43.2
Lap appendectomy	57.68	195.6
Laparotomy	22.22	140.8

**VENOUS THROMBOEMBOLISM HAS HIGHER RATES OF MORTALITY IN EMERGENCY GENERAL SURGERY THAN TRAUMA PATIENTS**

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**Introduction:** Deep venous thrombosis (DVT) and pulmonary embolism (PE) are commonly referred to as venous thromboembolism (VTE). Acute care surgeons are constantly challenged by the adverse impact of VTE in both trauma and emergency general surgery (EGS) patients. There is a lack of comparative studies between these 2 high risk patient populations. We hypothesized that VTE patients have worse hospital outcome in trauma than EGS patients.

**Methods:** Prospectively collected EGS and trauma database from 2005 through 2018 were queried for patients diagnosed with acute DVT and PE. Demographics, diagnostic imaging (venous duplex ultrasound and chest CT with contrast), VTE prophylaxis, procedures (inferior vena cava filter placement) and outcomes were extracted. Student's T-test was used for continuous variables. Chi-square and Fisher exact test were used for categorical variables. Multivariable regression was applied. Statistical significance was set at  $p < 0.05$ .

**Results:** A total of 1,135 patients (Trauma = 72%, EGS= 28%) with VTE (853 acute DVT, 144 PE, 138 both DVT and PE) were identified. There was no significant difference between the incidence of VTE between both groups (2.05% vs 2.19%,  $p=0.3$ ). Males were more likely to have VTE in the trauma group (73.07% vs 55.35%,  $p=0.0001$ ). EGS patients were also older ( $60.82 \pm 14.70$  vs  $53.77 \pm 20.16$ ,  $p=0.0001$ ), with higher BMI ( $31.24 \pm 9.77$  vs  $28.75 \pm 7.20$ ,  $p=0.0001$ ), and Charlson comorbidity index ( $4.95 \pm 3.09$  vs  $2.85 \pm 2.68$ ,  $p=0.0001$ ). Venous duplex ultrasound screening for DVT (16.83% vs 4.05%,  $p=0.006$ ), pharmacologic VTE prophylaxis (43.35% vs 19.65%,  $p=0.001$ ), and inferior vena cava filter placement (4.67% vs 1.15%,  $p=0.1$ ) were significantly higher in trauma patients. There was no difference in length of stay (LOS) between both groups ( $21.66 \pm 19.59$  vs  $20.64 \pm 16.65$ ,  $p=0.4$ ), however, trauma patients had longer intensive care unit (ICU) LOS ( $12.18 \pm 13.81$  vs  $9.63 \pm 13.20$ ,  $p=0.004$ ). Mortality in EGS patients was significantly higher when compared to trauma (16.0% vs 7.5%,  $p=0.0001$ ). After adjusting for age, gender, BMI and Charlson comorbidity index, VTE was found to be an independent risk factor for increased mortality in both EGS and trauma patients. EGS patients, however, were found to be at an even higher risk of mortality when diagnosed with VTE (OR 5.4; 3.792-7.683,  $p=0.0001$ ) vs trauma group (OR 2.6, 1.990-3.469,  $p=0.0001$ ).

**Conclusions:** Although the incidence of VTE in trauma patients is slightly higher than EGS patients, this most likely is related to more aggressive VTE screening and prophylaxis protocols as EGS patients are not routinely screened nor aggressively prophylaxed. EGS patients with VTE have worse hospital outcomes with a 2-fold increased risk of mortality when compared to trauma patients. Therefore, we strongly recommend more aggressive VTE screening and prophylaxis in EGS patients. Further prospective research is required to justify these findings.

**IMPROVED ACCESS TO POST-HOSPITAL CARE AFTER ACA OPEN ENROLLMENT FOR EMERGENCY GENERAL SURGERY PATIENTS**

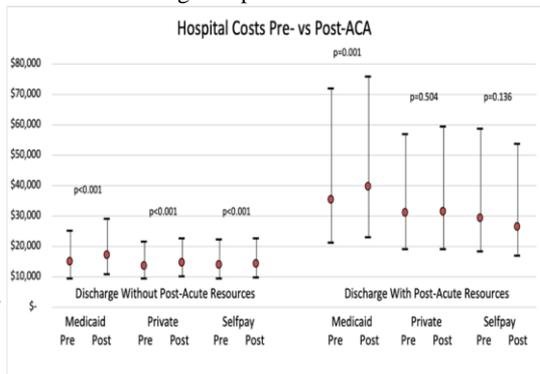
Laura N. Godat\* MD, Allison E. Berndtson MD, Alan Smith Ph.D., Jay J. Doucet\* MD, Todd W. Costantini\* MD, University of California, San Diego

**Introduction:** Patients undergoing Emergency General Surgery (EGS) are at high risk for post-operative morbidity including prolonged recovery and need for post discharge care. The Affordable Care Act Open Enrollment (ACA) began in 2014 and increased health insurance coverage. The effect of the ACA on access to post-acute care for EGS patients is largely unknown. We hypothesized that increased insurance coverage post-ACA would be associated with increased access to post-acute care services including skilled nursing facilities, long-term care facilities and home health care.

**Methods:** The Nationwide Inpatient Sample Database 2012 – 2015 was queried for all adult admissions age 18-65 with an abdominal EGS ICD-9 diagnosis code as defined by the AAST. Only patients who underwent one of seven common abdominal EGS operative procedures (colon resections, small bowel resections, open cholecystectomy, ulcer repair, lysis of adhesions, open appendectomy or laparotomy) were included. Analyses included demographics, hospital length of stay (LOS), payer type (Medicaid, Private, Self-pay), complications, Charlson comorbidity index and need for post-acute care services. Differences in differences (DID) analysis was used to assess for change post-ACA OE in 2014.

**Results:** There were 88,074 operative EGS admissions. The pre- vs post-ACA payer mix changed significantly; Medicaid coverage increased (27.7% to 32.4%,  $p<0.001$ ), and Self-pay decreased (14.7% to 10.5%,  $p<0.001$ ), while Private insurance did not change significantly (57.5% vs 57.1%,  $p=0.159$ ). Discharges with post-acute care services significantly increased post-ACA for Medicaid (26.2% to 29.7%  $p=0.002$ ) and Private groups (23.5% to 26.7%  $<0.001$ ) but not Self-pay payer types (11.2% to 12.3%  $p=0.086$ ). For those discharged with post-acute care services the only payer type with significantly increased cost was Medicaid (pre-ACA \$35,290, IQR 21,052-71,529 & post-ACA \$39,528, IQR 22,563-75,626,  $p=0.001$ ), see Figure. Post-ACA DID analysis demonstrates significantly increased discharges to post-acute care services and over-all adjusted costs but no significant change in LOS.

**Conclusion:** The ACA improved access to post-acute care services, however did not reduce LOS or decrease costs for EGS admissions. Future studies should not just examine the role of healthcare insurance policies on access to inpatient EGS care but also on access to the continuum of care including post-acute care services.



## USING AAST GRADE TO DETERMINE NEED FOR OPERATIVE INTERVENTION IN AMI

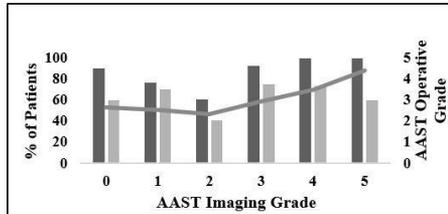
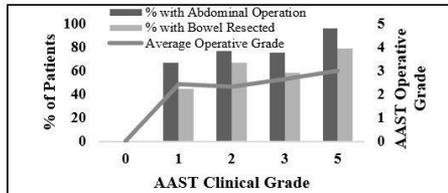
Morgan E. Sindall BS, Payden Wallace MD, Daniel L. Davenport Ph.D., Andrew C. Bernard\* MD, University of Kentucky

**Introduction:** Acute mesenteric ischemia (AMI) is highly mortal and may be difficult to diagnose. Treatment is based on etiology and severity of ischemia. AAST proposed a grading scale intended to determine treatment and predict outcomes based on clinical, imaging, operative and pathology findings. We have previously shown that overall AAST grade was not well correlated with outcomes, but operative grade strongly predicted of mortality. We have also shown that interrater agreement was low, presumably due to subjectivity in the clinical grading and the omission of specific findings in the imaging criteria. The aim of this study was to determine if AAST clinical and imaging grades could aid in identifying patients who need immediate operative intervention.

**Methods:** We conducted a single center retrospective chart review. Patients were selected using ICD 9 and 10 codes for acute mesenteric ischemia (ICD10-K55.0, ICD9-557.0). Inpatients >17 years old from the years 2008-2015 were included. AAST grades were assigned after review of clinical, imaging, operative and pathology findings. Clinical grades 4 and 5 had identical descriptions, so in these cases were given a grade of 5. Two raters applied the scales independently after dialog with consensus on the correct grading of several difficult cases. Mortality was recorded.

**Results:** A total of 221 patients were analyzed. All patients requiring an operation presented with abdominal pain (clinical grades 1-5) (Figure 1). The percent of patients requiring bowel resections increased from 44-79% with clinical grades 1-5 ( $r=0.87$ ,  $p=0.13$ ). Clinical grade 5 (peritonitis) had the highest average operative grade (Figure 1). 10 patients with AMI had a negative CT (AAST imaging grade 0) and 60% of those required a bowel resection. All patients with AAST imaging grades above 4 or 5 underwent an abdominal operation, and had increasing average operative grades ( $r=0.38$ ,  $p<0.001$ ) (Figure 2)

**Conclusions:** AAST clinical grades below 3 do not rule out the need for operative intervention, but the absence of abdominal pain (AAST clinical grade 0) can provide reassurance that critical ischemia is not present. Clinical exam findings in AMI are not useful in quantifying disease severity except in clinical grade 5 (peritonitis). Normal CT imaging (AAST imaging grade 0) cannot rule out the need for operative intervention and only AAST imaging grades 3-5 indicate severe bowel wall injury requiring surgery. Changes allowing for better discrimination of AAST imaging grades 1-3 would aid in determining the need for operative intervention in patients with indiscriminate clinical findings in AMI.



**IMPACT OF OPERATIVE DELAY ON MORBIDITY AND MORTALITY AFTER COMMON EMERGENCY GENERAL SURGERY OPERATIONS**

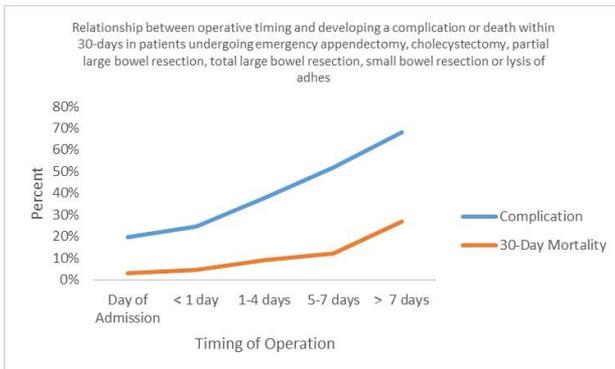
Patrick B. Murphy MD, MPH, MSc, Stephanie Savage\* MD, Jennifer L. Hartwell\* MD, Rachel D. Rodriguez MD, Ben L. Zarzaur\* Indiana University School of Medicine

**Introduction:** Little is known regarding the impact delay to definitive treatment may have on patient morbidity and mortality in the emergency setting. Frailty may impact operative timing in the emergency setting. Our objective was to determine the association between timing of operative intervention frailty on 30-day morbidity and mortality in adult patients undergoing emergency general surgery.

**Methods:** We performed a retrospective cohort study of patients older than 40 years of age from 2010-2014 in the National Surgical Quality Improvement Program (NSQIP) who underwent appendectomy, cholecystectomy, large bowel resection, small bowel resection or lysis of adhesions on an emergent basis. The modified frailty index (mFI) was used to stratify patients into low, intermediate and high frailty states. Patients were stratified by timing of operation (day of admission, within 24 hours, 1-4 days, 5-7 days and after 7 days). A multi-variable regression was performed to determine the association of operative timing, frailty and serious complication.

**Results:** A total of 57 173 patients underwent appendectomy (46%), cholecystectomy (14%), large bowel resection (21%), small bowel resection (11%) or lysis of adhesions (8%) on an emergent basis. Overall, 25% of patients experienced a complication, 3.2% died in hospital and 5.1% died within 30 days. Complications and 30-day mortality increased based on timing of operation (Figure 1). On regression, the odds of 30-day mortality and complication were higher when surgery was performed further into the patients' admission, and this persisted across all operations. For lysis of adhesions thirty-day mortality was significantly increased only when the operation was performed seven days after admission (OR 4.2, 95%CI 2.8-6.4). There was no interaction between mFI and operative timing for any procedure.

**Conclusion:** Delays in definitive operative treatment are associated with worse outcomes in patients undergoing emergency general surgery. Frail patients were more likely to be delayed but not to suffer complications related to delay. Emergency surgery should not be delayed even in frail patients.



## **OPERATING ROOM UTILIZATION FOR EMERGENCY GENERAL SURGERY CASES: ANALYSIS OF THE PATTERNS OF COMPLEX EMERGENCY GENERAL SURGERY IN CANADA STUDY**

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**Introduction:** Emergency General Surgery (EGS) patients represent a large cohort that requires acute hospital and operating room (OR)-based disease management. Access to ORs is variable amongst EGS services, with some having dedicated EGS ORs and others placing their patients in an Emergency OR queue that all specialties share. The operative burden of EGS and differences associated with differential access to ORs has not previously been described in Canada.

**Methods:** The Patterns of Complex Emergency General Surgery in Canada Study is a multicenter retrospective cohort study evaluating patients operated on by EGS services at seven Canadian centres. Adult patients (>18 years) undergoing non-elective operative intervention for non-biliary, non-appendiceal disease were included. We used this cohort to: 1) describe booking priorities (2-8 hours; 8-24 hours; 24-48 hours) and timing of operative intervention; 2) to compare centers with and without access to a dedicated EGS daytime OR; and 3) to identify differences in morbidity and mortality based on timing of operative intervention. We excluded trauma cases and those booked with the highest priority (<2 hours). Timing of operative intervention was classified as: weekday daytime (8am-5pm); weekday evening (5pm-11pm), overnight (11pm-8am) and weekend day/evening (8am-11pm).

**Results:** Overall, 1244 patients were included in this analysis, with operations performed during weekday daytime in 521 (42%), weekday evenings in 279 (22%), overnight in 151 (12%), and weekend day/evening in 293 (24%). The OR booking priority was 2-8 hours in 657 (53%), 8-24 hours in 334 (27%), and 24-48 hours in 253 (20%). There was substantial variation in booking priority seen for patients with hernia (53% 2-8 hours; 27% 8-24 hours; 20% 24-48 hours), small bowel obstruction (66% 2-8 hours; 20% 8-24 hours; 14% 24-48 hours), and diverticular disease (50% 2-8 hours; 31% 2-8 hours; 19% 24-48 hours). Centers with dedicated EGS ORs performed a greater proportion of cases during daytime hours than those without dedicated EGS ORs ( $p=0.009$ ). This difference was most pronounced for those cases booked with priority 8-24 hours ( $p<0.001$ ), with no statistical difference in proportions for those cases booked with priority 24-48 hours ( $p=0.101$ ). Amongst operative cases booked with a priority of 2-8 hours and 8-24 hours, there were no significant differences between cases during the daytime, evening, and overnight with respect to mortality rate, complication rate, and length of stay.

**Conclusion:** The operative burden of EGS patients in Canada is significant. For EGS patients with pre-operative diagnoses of hernia, bowel obstruction, or diverticular disease, there exists considerable variation of OR booking priority. Centers with dedicated EGS ORs perform more of their cases during the daytime, however there is no evidence of compromised outcomes based on OR timing.

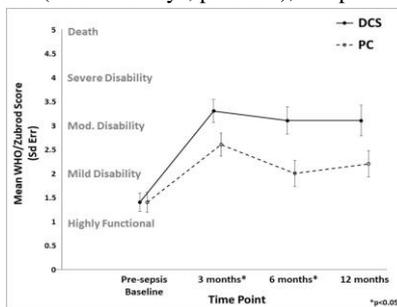
## CURRENT INDICATIONS, UTILIZATION AND LONG-TERM OUTCOMES OF DAMAGE CONTROL SURGERY AND TEMPORARY ABDOMINAL CLOSURE FOR INTRABDOMINAL SEPSIS

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**Introduction:** Damage control surgery and temporary abdominal closure (DCS) has become standard of care for trauma patients with multi-system injuries in physiologic extremis. DCS has been subsequently applied to the surgical management of intra-abdominal sepsis (IAS), but the appropriate indications, current utilization and long-term outcomes of DCS in this setting remain unclear.

**Methods:** We analyzed all IAS patients enrolled into a longitudinal, prospective cohort of critically ill surgical sepsis patients (n=126/302). IAS patients were classified as managed non-operatively (NO; n=34), with primary closure (PC; n=44), or with DCS (n=48). Patient characteristics, management parameters, and outcomes out to 12-months were compared between groups.

**Results:** Baseline demographics were similar between groups. Compared to PC, DCS had a higher incidence of septic shock (47.9 vs 15.9%, p=0.0005) and greater physiologic derangement within the first 24 hours (APACHE II; 20 vs 15.5, p=0.0029), as well as greater MOF incidence (Denver2; 83% vs 34%, p<0.0001) and severity (Max. SOFA; 11 vs 5, p<0.0001). The primary indications for utilizing DCS were 'required 2<sup>nd</sup> look' (43.8%), 'excessive gross contamination' (25%), and physiologic extremis (20.8%). Subsequent fascial closure was achieved in 75% (n=36/48) of DCS. Inpatient mortality was significantly higher in DCS (23 vs 4.5%, p=0.0154). Additionally, resource utilization was higher in DCS regarding ICU LOS (13.5 vs 5 days, p<.0001), Hospital LOS (20 vs 15 days, p=0.0073) and 'poor' discharge disposition (LTAC/SNF/hospice; 73 vs 36%, p=0.0007). Additionally, DCS patients had significantly fewer 12-month hospital-free days (298 vs 344.5, p=0.0005), higher 12-month mortality (43.8 vs 15.9%, p=0.006), and poorer physical functional status at 6-months (**Figure**; WHO/Zubrod score, 3.1 vs 2.2, p=0.025). Both groups failed to return to baseline functional status by 12 months.



**Conclusion:** Primary fascial closure rates remain suboptimal after DCS for IAS. Mortality at 12-months after DCS is nearly double that at discharge. Functional deficits persists in DCS patients out to 1-year after surgical sepsis. Strategies to emphasize achieving fascial closure, assuring post-discharge rehabilitation, and diligent post-discharge follow-up is likely required to improve long-term outcomes among these patients.

## **IMPACT OF INTERHOSPITAL TRANSFER ON PATIENT OUTCOMES IN EMERGENCY GENERAL SURGERY**

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**INTRODUCTION:** Emergency General Surgery (EGS) patients are at an increased risk for morbidity and mortality compared to their elective surgery counterparts. The complex nature of EGS conditions can challenge community hospitals which may lack appropriate systems of care. Outcomes related to transfer have not been well established. The aim of the current study is to compare outcomes of patients transferred to a center with dedicated acute care surgery (ACS) services with patients directly admitted to ACS Centers.

**METHODS:** We performed a secondary analysis of a previously collected national multi-center retrospective review of all emergency general surgery patients undergoing non-biliary, non-appendiceal EGS at five centers across Canada over one year (Jan 1 – Dec 31, 2014). Demographic and baseline comorbidities were collected, as were details of admission and operative interventions. In-hospital mortality, intensive care unit length of stay, and hospital length of stay were also collected. For patients transferred from another center, procedures performed at the transferring center (including operative interventions) were also collected. The adjusted odds of post-operative complication, Intensive Care Unit (ICU) admission, and death were assessed using logistic regression to determine the independent effect of transfer status, controlling for age, comorbidities, American Society of Anesthesiologists (ASA) classification and booking priority.

**RESULTS:** A total of 1846 patients were included in the study, and 176 (9.5%) were transferred. Of these 15% (n=27) underwent an operation at the transferring center. Transferred patients were more likely to have at least one comorbidity (68% vs. 57%;  $p=0.004$ ), were classified as higher urgency for the OR at the ACS centre (<2hrs booking priority, 43% vs. 17%;  $p<0.001$ ), had a higher ASA classification (ASA  $\geq 3 = 81\%$  vs. 65%;  $p<0.001$ ), a longer OR length (119 vs. 110 minutes;  $p=0.004$ ), and were more likely to undergo a second operation (28% vs. 14%;  $p<0.001$ ) compared to patients directly admitted to an ACS center. On univariate analysis, transferred patients had higher rates of complications (44% vs. 29%,  $p<0.001$ ), mortality (14% vs. 7%,  $p=0.005$ ) and admission to the ICU (22% vs. 12%,  $p<0.001$ ). Transfer status remained an independent predictor of complication (OR 1.9 (95% CI 1.3-2.7);  $p<0.001$ ) and ICU admission (OR 2.2 (95% CI 1.4-3.3);  $p<0.001$ ), but not mortality (OR 1.1 (95% CI 0.6-1.9);  $p=0.67$ ) on regression analysis.

**CONCLUSIONS:** Complex EGS patients transferred to ACS centers have worse outcomes and higher resource use compared to those directly admitted. This has significant implications for the design and regionalization of ACS services as well as resource allocation at ACS centers.

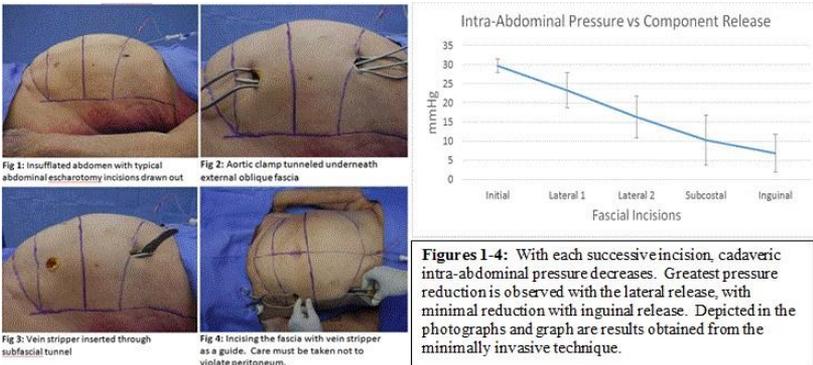
## A NOVEL ABDOMINAL DECOMPRESSION TECHNIQUE TO TREAT COMPARTMENT SYNDROME AFTER BURN INJURY

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**Introduction:** In severely burned patients (TBSA >20%), the prevalence of abdominal compartment syndrome (ACS) is estimated to be 4-17%, approaching 100% mortality if left untreated. Although decompressive laparotomy can be a life-saving measure for many patients with ACS, severe complications may be associated with this technique. Specifically, in the burn population open laparotomy incisions for ACS portend extremely high mortality (up to 100%). This study outlines a new technique of releasing intra-abdominal pressure without resorting to decompressive laparotomy.

**Methods:** A total of ten fresh tissue cadavers were treated, none of whom had had prior abdominal surgery. Escharotomy incisions were marked with ink and the fascial incision locations were identified for anterior component separation, subcostal and inguinal locations. The abdomen was then entered at the subxiphoid location using a Veress needle, confirmed to be in the peritoneal cavity via aspiration and saline drop test and secured with a U-stitch through the skin around the needle. The needle was connected to an arterial pressure transducer, zeroed at the anterior axillary line, and the abdomen was insufflated to a pressure of 30 mmHg. We used two techniques to incise fascia, first with the raising of large skin flaps from a midline incision (N = 5 cadavers) and second, with direct small 2 cm cutdowns at the proximal and distal extent of the incisional sites, dissecting and tunneling in a subfascial plane using an Aortic clamp and then cutting the fascia underneath the skin through the grooves of a tunneled vein stripper (N = 5 cadavers). Pressures were then recorded in after each of the fasciotomies, performed in sequence (bilateral anterior component separation 1st, bilateral subcostal 2nd and bilateral inguinal 3rd). Data is represented as mean  $\pm$  standard deviation and compared using Mann Whitney U-Test.

**Results :** Using the open midline flap technique the abdominal pressure decreased from a mean pressure of  $30 \pm 1.8$  mmHg to  $6.9 \pm 5.0$  mm Hg (overall reduction of pressure from 23 mmHg to 12 mmHg,  $p < 0.01$ ). Using the minimally invasive technique, a net decrease of intra-abdominal pressure from  $30 \pm 0.9$  to  $5.8 \pm 5.2$  mmHg was observed (overall reduction of 29 mmHg to 8.0 mmHg,  $p < 0.01$ ). The results are shown in **Figures 1-4** below.



**Conclusion:** We describe a novel technique to reduce intra-abdominal pressure via extra-peritoneal component separation and fascial release at the subxiphoid and inguinal regions. This technique offers the benefit of not subjecting the patient to the morbidity and mortality of decompressive laparotomy and the complications associated with an open abdomen, which may be beneficial in the burn injury population. Future study is warranted.

**COMBATING THE OPIOID EPIDEMIC IN THE ACUTE CARE SURGERY PATIENT: REFRAMING INPATIENT ACUTE PAIN MANAGEMENT**

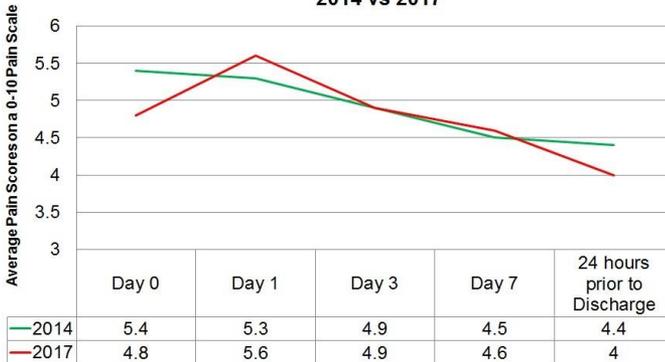
BrookeAnne Magrum PharmD, Lisa Mostafavifar PharmD, Kristin Brower PharmD, Chelsea Horwood MD,MPH, Michelle Nguyen MD,MPH, Anna Buehl RN, Daniel Eiferman\* MBA,MD, Ohio State University

**Introduction:** The devastating effects of the opioid epidemic have been well documented. Opioid reduction initiatives have focused primarily on the outpatient setting. Patients undergoing surgery in an acute setting are unique in that pre-operative counseling and enhanced recovery after surgery (ERAS) protocols are limited due to the emergent nature of the procedure. We attempted to reduce the number of total inpatient opioids prescribed by implementing a Surgeon/Pharmacist Opioid Reduction Initiative at a tertiary academic medical center by incorporating multi-modal pain therapy and focus on functionality. We hypothesized that significantly less opioids would be prescribed post-operatively without affecting pain scores or length of stay.

**Methods:** This is a single-center observational cohort analysis. Patients admitted to the acute care surgical service and underwent one of ten emergent general (non-trauma) surgical operations were included. Differences in daily oral morphine equivalents (OMEs), OMEs prescribed at discharge, average pain scores, and length of stay were compared between pre-initiative and post-initiative groups. Statistical analyses were performed using the Mann-Whitney U Test for non-parametric, non-normally distributed data.

**Results:** Eighty-five patients in the pre-initiative group and ninety-nine patients in the post-initiative group met inclusion criteria. Our preliminary results showed decreased opioid utilization in the post-initiative compared to the pre-initiative on all observed post-operative days. Average pain scores were similar on every post-operative day despite less opioid use (see figure 1). The median OME prescribed at discharge decreased significantly from 450 [378 – 731] in the pre-initiative vs. 400 [225-630] in the post-initiative (p = 0.02) corresponding to a decreased number of days' supply of opioids from 7 [5-10] to 6 [3-8] (p = 0.03). Median length of stay was not significantly different between the two groups (4 [1-7] vs. 5[2-9]; p = 0.14).

**Comparison of Average Pain Scores in patients during 2014 vs 2017**



**Conclusions:** An inpatient Opioid Reduction Initiative was successful in lowering the amount of opioids prescribed during hospitalizations and upon discharge without affecting pain scores or length of stay in patients undergoing unplanned general surgery procedures. Our multidisciplinary initiative can be easily implemented at other institutions to help combat the opioid epidemic.

**INCREASED RESOURCE UTILIZATION FOLLOWING ACUTE  
CHOLECYSTECTOMY IN MEDICAID PATIENTS: A  
PROPSENSITY-SCORE-MATCHED ANALYSIS.**

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**INTRODUCTION:** Medicaid payer status has been shown to affect risk-adjusted outcomes and costs across multiple specialties. The Medicaid Expansion created by the Affordable Care Act has significantly increased Medicaid enrollees. The purpose of this study was to examine resource utilization via readmission rates, length of stay, and total cost specific to Medicaid payer status following cholecystectomy for acute cholecystitis.

**METHODS:** The Nationwide Readmissions Database (NRD) was used to identify patients who underwent cholecystectomy for acute cholecystitis in 2016, as well as "Medicaid" or "non-Medicaid" payer status. Demographic data, comorbidities, readmission rates, length of stay (LOS), hospital characteristics and adjusted costs were evaluated. A propensity score was utilized to control for confounding variables between payer groups on the basis of the available baseline demographic to match non-Medicaid control patients to Medicaid patients. Following propensity score matching, the chi-square test was used to compare readmission rates between the payer groups. The relative risk (RR) with 95% confidence interval (CI) was estimated to quantify readmission risks. LOS and adjusted cost comparisons were evaluated using the Wilcoxon signed-rank test.

**RESULTS:** A total of 6,056 Medicaid and 30,537 non-Medicaid patients receiving open or laparoscopic cholecystectomy for acute cholecystitis were identified. Propensity matching resulted in 2,798 pairs of Medicaid and non-Medicaid patients. 60-day readmission rates were higher for Medicaid compared to non-Medicaid payer status (8.1% versus 5.3%,  $p = 0.0001$ ); with a RR of readmission of 1.53 (CI: 1.25 to 1.87). Readmission at 60-days for a post-operative complication was more common in Medicaid patients (6.5% versus 3.9%,  $p = 0.0001$ ) with a RR of 1.69 (CI: 1.29 to 2.19). Mean total LOS was longer for Medicaid than non-Medicaid patients at 6.4 versus 5.3 days,  $p < 0.0001$ . Total adjusted costs were higher for Medicaid than non-Medicaid patients at \$14,213 (IQR: \$9,275-24,004) versus \$11,230 (IQR: \$7,619-17,985),  $p < 0.0001$ .

**CONCLUSIONS:** This study demonstrates that Medicaid payer status is independently associated with increased resource utilization, including readmission rates, LOS, and total adjusted costs following cholecystectomy for acute cholecystitis. Incorporating Medicaid payer status into risk adjustment models is needed to avoid access disparities and financial disincentives to hospitals and providers.

## PAIN MANAGEMENT ON A TRAUMA SERVICE: A CRISIS REVEALS OPPORTUNITIES

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**Introduction:** The opioid crisis has forced an examination of opioid prescribing and usage patterns. Multimodal pain management and limited, procedure-specific prescribing guidelines have been proposed in general surgery. This has been less well studied in trauma, where multisystem injuries and multispecialty caregivers are the norm. We hypothesized that opioid requirements would differ by primary type of injury, and we sought to identify factors affecting opioid prescribing at discharge (DC).

**Methods:** Retrospective analysis of pain management was performed at a level II trauma center for January-November 2018. Consecutive patients (pts) with exploratory laparotomy (LAP); 3 or more rib fractures (fxs) (RIB); or pelvic (PEL), femur (FEM), or tibia (TIB) fxs were included, assigned to cohorts based on the predominant injury. Pts who died, or had head AIS >2 and GCS <15, were excluded. All pain medications were recorded daily; narcotic doses were converted to oral morphine equivalents (OMEs). OMEs administered over the final 72 hrs of hospitalization (OME72) and prescribed at DC (OMEDC) were calculated. Data presented as means. Categorical variables were analyzed using Fischer's Chi Square and continuous variables with an unpaired *t*-test. A *p* value <0.05 was considered significant (indicated by “\*”).

**Results:** 208 pts were included: 17 LAP, 106 RIB, 31 PEL, 26 FEM, and 28 TIB. 74% were male. Females were older than males (65 vs 51\*) and had shorter length of stay (LOS) (4.5 vs 7.3\*). 16 (8%) were using opiates prior to admission. Injury cohorts varied by age but not ISS or LOS (Table). 67% of pts received multimodal (ie, 3 or

	N	Age	ISS	LOS	OME72	OMEDC
LAP	17	29*	12	7.2	211	199
PEL	31	56	12	9.5	267	263
FEM	26	39	15	7.0	185	252
TIB	28	41	13	11.1	191	260
RIB	106	65*	12	4.3	92*	237
<b>Total</b>	<b>208</b>	<b>54</b>	<b>12</b>	<b>6.6</b>	<b>189</b>	<b>243</b>

more drugs) pain therapy. OME72 was lower for RIB compared with all other cohorts and did not vary based on number of rib fxs (3-8+). Older (>64 yrs) patients had similar ISS and LOS, but lower OME72 (74 vs 190\*) and OMEDC, compared with age <65. There was no relationship between OME72 and OMEDC across injury groups, or by sex or injury severity. In fact, females and those with ISS <16 had slightly lower OME72 yet slightly higher OMEDC. Patients were discharged almost exclusively by trauma service advanced practice clinicians (APCs). There was no difference among APCs in number of pills or OMEs prescribed. 81% of pts received opioids at DC; 69% of them were prescribed an opioid/ acetaminophen (ACET) combination drug. Only 13% were prescribed NSAIDs, 19% ACET, and 31% gabapentin (GABA) at DC.

**Conclusion:** Pts with different injury types have varied opioid requirements. Opioid DC prescribing appears rote and does not correlate with actual opioid usage during the 72hrs prior to DC. Paradoxically, OMEDC tends to be higher among females, pts with ISS <16, and those with rib fxs, despite a tendency toward lower OME72 usage among these groups. ACET, NSAIDs and GABA are underutilized. These findings highlight opportunities for improvement and further study.

## MULTI-SYSTEM ORTHOPEDIC INJURIES: A RISK FACTOR FOR PROTRACTED OPIOID USE IN OPIOID NAIVE TRAUMA PATIENTS

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**Introduction:** Opioids are a mainstay in the management of pain in the injured and were until recently liberally prescribed. The emergence of opioid abuse as a public health crisis of epidemic proportions has led us to rethink this approach. Clinicians now face the challenging task of balancing the need to provide pain relief with that of preventing opioid addiction. There is an urgent need to identify patients at risk for protracted opioid use. We hypothesized that the pattern of injury would be predictive of protracted opioid use.

**Methods:** With IRB approval, a retrospective review of trauma registry data at our suburban level II trauma center for the period 2013-2016 was performed. Registry data was cross referenced with data in the state prescription drug monitoring program. Protracted opioid use was defined by ongoing use greater than 120 days after the injury. Univariable analysis followed by multivariable analysis was performed. A p value of <0.05 was deemed significant.

**Results:** Of 3970 patients, 1131 had complete data available, were opioid naive at the time of injury, and constituted the study population. Protracted opioid use was identified in 164 (14.5%) and was significantly more frequent in those sustaining multisystem orthopedic injuries (51.83% vs. 41.05%,  $p<0.002$ ). Prolonged use was not observed in patients with isolated vertebral column injuries or isolated pelvic fractures, traumatic brain injuries, or rib fractures (all  $P=NS$ ). Female gender ( $p=0.03$ ), older age ( $p=0.02$ ) and having insurance ( $p=0.01$ ) were also associated with protracted use. Post-discharge opioid prescriptions were more frequently obtained from a service other than the primary trauma Service (1.8% vs 82.0%,  $p<0.0001$ ).

**Conclusion:** Opioid naïve trauma patients that sustain multi-system orthopedic injuries are significantly more likely to use opioids on a protracted basis. Women, older patients, and those with insurance are also at greater risk. Aggressive prevention measures including a multimodal opioid sparing approach to analgesia, and the coordination of opioid prescribing across services with aggressive review of state prescription drug monitoring program data appears to be warranted, especially in this patient population.

	Protracted Opioid Use N=164(14.5%)	No Protracted Opioid Use N=967(85.5%)	P value.
Age (Years)	52.43±18.51	48.87±21.14	0.02
Female	77(46.95%)	344(35.57%)	0.03
Insured	145(88.41%)	793(82.01%)	0.01
Injury Severity Score	7.16± 6.87	7.18± 7.01	0.87
Pre-Injury Schedule 2 Drug Use	11 (6.71%)	81 (8.38%)	0.17
Multisystem Orthopedic Injury	85(51.83%)	397(41.05%)	0.0002
Isolated Vertebral Column Injury	25 (15.24%)	122(12.62%)	0.89
Isolated pelvic fracture	41 (25.00%)	5 (0.52%)	0.61
Traumatic Brain Injury	26(15.85%)	112(11.58%)	0.3
Rib fractures	24(14.63%)	152(15.72%)	0.6
ICU admission	38(23.17%)	181(18.72%)	0.37
ICU length of stay	3.64± 4.04	4.02± 5.35	0.88
Hospital length of stay	4.01± 4.48	3.52± 4.22	0.18
Number of Prescriptions Filled	25.36± 28.26	5.79± 11.64	0.0001
Number of prescribers	10.5± 18.92	3.04± 3.64	0.0001

## **LOSS OF LYMPHOCYTES CAN PREDICT COMPLICATIONS**

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**Introduction:** Lymphocyte responses following trauma have been shown to predict mortality. Clinicians use a multitude of factors to determine when a patient's clinical status is declining. We hypothesize that a drop in lymphocyte count will predict complications in trauma patients.

**Methods:** Retrospective review of our trauma registry from January 2010 through March 2015 for patients with at least two lymphocyte counts obtained within four days of traumatic injury. Their four day lymphocyte patterns were grouped by those who were always normal, those who became lymphopenic but recovered, and patients who remained lymphopenic. The primary outcomes of all-cause mortality, any complication, and any infection and any morbidity were assessed by Kaplan-Meier curves. Complications and infections were defined by those present in the trauma registry. Lymphocyte counts were also correlated with neutrophil counts from the same lab draw and then the highest count the next day.

**Results:** 9373 trauma patients demonstrated a three-tiered mortality based on lymphocyte response across all trauma patients regardless of ISS. Patients who were never lymphopenic had the lowest 30 day mortality (4.3%), recovered lymphopenia higher mortality (13.4%), and the persistent lymphopenia group the highest (25.3%,  $p \leq 0.0016$  for all comparisons). The complication rate in patients with recovered lymphopenia (48.7% rate) and persistent lymphopenia (50.4% rate) are similar, but both are significantly more than patients who had a normal lymphocyte count (29.3%,  $P < 0.001$  for both comparisons). A similar pattern was found for any infection on the Kaplan-Meier curves. Additionally, a drop in lymphocyte count predicted a rise in the neutrophil count one day later.

**Conclusions:** Clinicians use many tools to assess the severity of illness in patients and now a drop in lymphocytes can be utilized to predict a complication as well as mortality in all trauma patients. This lab finding should prompt clinicians to thoroughly re-evaluate their patients for factors that contribute to excess mortality.

**TRAUMA HIGH RESOURCE CONSUMERS – A DRAIN ON THE SYSTEM**

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**INTRODUCTION:** Extended hospital length of stay (LOS) is widely associated with significant healthcare costs. Since LOS is a known surrogate for cost, we sought to evaluate outliers. We hypothesized that particular characteristics are likely predictive of trauma high resource consumers (THRC) and can be used to more effectively manage care of this population.

**METHODS:** The Pennsylvania Trauma Outcome Study database was retrospectively queried from 2003-2017 for all adult (age ≥15) trauma patients admitted to accredited trauma centers in Pennsylvania. THRC were defined as patients with hospital LOS two standard deviations above the population mean or ≥22 days (p<0.05). Patient demographics, comorbid conditions and clinical variables were compared between THRC and trauma non high resource consumers to identify potential predictor variables. A multilevel mixed-effects logistic regression model controlling for age, gender, injury severity, admission Glasgow coma score (GCS) and systolic blood pressure assessed the adjusted impact of clinical factors in predicting THRC status.

**RESULTS:** 489,027 patients met inclusion criteria [THRC: 17,544 (3.59%); non-THRC: 471,483 (96.41%)]. Compared to non-THRC counterparts, THRC patients were significantly more severely injured (ISS: 10.58 vs. 22.53, p<0.001) and had a higher incidence of chronic alcohol abuse. In adjusted analysis, gunshot wound to the abdomen, undergoing major surgery and reintubation were significantly associated with THRC (Table 1). Penetrating injury overall was associated with decreased risk of being a THRC.

**CONCLUSION:** Reintubation, major surgery and gunshot wounds to abdomen are strongly predictive of THRC. Understanding the profile of the THRC will allow clinicians and case management to proactively put processes in place to streamline care and potentially reduce costs and LOS.

Trauma super-user		
Variable	AOR (95% CI)	p
GSW (abdomen)	1.509 [1.345-1.695]	<0.001
Penetrating MOI	0.486 [0.448-0.527]	<0.001
Major surgery	3.117 [2.974-3.267]	<0.001
Reintubation	9.834 [9.193-10.529]	<0.001
Age	1.002 [1.001-1.003]	<0.001
Male sex	1.411 [1.351-1.474]	<0.001
ISS		
0-8	Reference	---
9-15	2.495 [2.328-2.674]	<0.001
16-25	4.709 [4.396-5.045]	<0.001
26-75	9.792 [9.116-10.517]	<0.001
Admission GCS	0.937 [0.933-0.941]	<0.001
Admission SBP	1.000 [0.999-1.001]	<0.140
<b>AUROC: 0.865</b>		

## THE IMPACT OF THE AFFORDABLE CARE ACT ON TRAUMA OUTCOMES: AN INTERRUPTED TIMES SERIES ANALYSIS

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**Introduction:**Trauma disproportionately affects those of lower socioeconomic status and the uninsured. Compared to those with insurance, uninsured patients have worse long-term functional outcomes and increased mortality. The Affordable Care Act (ACA) was signed into law in 2010 with the goal of increasing access to insurance. Three provisions of the ACA that have had significant impact on increasing insurance access: the extension of Medicaid eligibility, the increased access to private insurance via income-based tax credits, and new insurance regulations that both ban discrimination on the basis of pre-existing conditions and mandate that all individuals have health insurance. These provisions took effect in January 2014. We sought to analyze the impact of these ACA provisions on trauma outcomes and investigate their impact on identified at-risk subgroups.

**Methods:**Using Diagnostic Related Groups, a time series was created from the Healthcare Cost and Utilization Project (HCUP) database between 2011-2016. An interrupted times series (ITS) was conducted at the population level, examining mortality, mean length of stay (LOS), and probability of discharge home with or without home health care using monthly time intervals with January 2014 as the intervention time. Data was organized into subgroups by income quartile (\$1-\$42,999; \$43,000-\$53,999; \$54,000-70,999; and \$71,000 or more USD) and race. ITS was used to analyze each group, using the opposing group as control groups. Results were adjusted for statistically significant covariables. Each model was examined for autocorrelation, and a range of lag times were applied in sensitivity analysis.

**Results:**After the 2014 provisions came into effect, at a population level there was a reduction in mortality (monthly probability reduction of 0.0145%: 95% CI 0.0246%-0.0370%). There were monthly increases in the probability of discharge with home health (0.0247%: 95% CI 0.0151%-0.0343%). The reduction in mortality was statistically significant in the non-white race group but was not significant in the white group. Both racial groups saw an increase in the probability of home health use; however, a discrepancy favoring the use of home health services amongst white persons was seen both pre- and post-intervention time (Figure). The lowest income quartile experienced no statistically significant change in the probability of being discharged home with or without home health, while the three highest quartiles all experienced increases. The greatest increases were demonstrated in the second income quartile.

**Conclusion:**The 2014 provisions have had an impact on mortality, which is driven by the effect in non-white racial groups. Markers of services, such as discharge home with home care, have increased across all racial groups, and specifically in middle and upper income quartiles. No changes were seen in the first income quartile, likely because these patients qualified for Medicare pre-ACA. There is a persistent discrepancy between racial groups in the use of home health services after traumatic injury.

**CALLING IT: FACTORS PRESENT WITHIN ONE HOUR OF ARRIVAL THAT PREDICT MORTALITY WITHIN THE NEXT FIVE HOURS**

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**Introduction:** Numerous studies have described predictors of overall mortality or early mortality within certain populations. However, this study aimed to identify variables present within 1h of hospital arrival that predict all-cause trauma mortality within 6h of hospital arrival. This may allow clinicians to better stratify risk of early mortality, which may be invaluable when debating the futility of care.

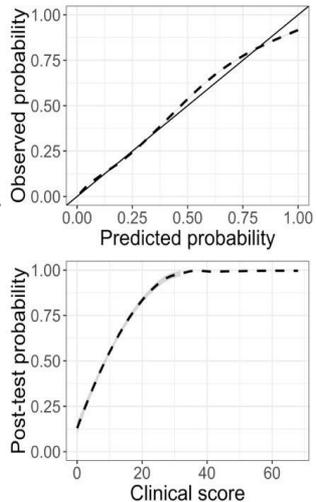
**Methods:** Using 2013-14 NTDB data, 1,225,903 encounters were analyzed after applying exclusions such as pre-hospital cardiac arrest, ED death within 15m, active DNR, death after 6h, and age <15. Using demographic, physiologic, anatomic, and procedural variables, we derived 485 potential predictors. Cross-validated variable selection was performed using binomial probit LASSO regression.

**Results:** 9,803 (0.80%) died within 6h. As shown in the table, initiating any of these five common procedures within 1h was associated with increased risk of 6h mortality. Major vascular injury to the trunk and respiratory assistance on arrival were also associated with higher

Variable	B (95% CI)	Clinical score
CPR within 1h	2.44 (2.37, 2.50)	24
Resp. rate assisted on arrival	1.05 (1.02, 1.07)	11
Exploratory thoracotomy within 1h	0.90 (0.80, 1.00)	9
Insert ET tube within 1h	0.62 (0.59, 0.65)	6
Any PRBC transfused within 1h	0.61 (0.56, 0.65)	6
Supplemental O2 on arrival	0.62 (0.59, 0.65)	6
Insert intercostal drainage catheter within 1h	0.37 (0.33, 0.42)	4
Injury to major vessels of the abdomen	0.93 (0.86, 0.99)	9
Injury to major vessels of the thorax	0.72 (0.66, 0.79)	7

risk. The model slightly under-estimates risk for encounters with actual probabilities 40-80% and over-estimates risk by <8% for encounters with actual probabilities >85% (top figure). Despite these small prediction errors, the model performed very well (AUC=0.97). The clinical score also performed well, but rounding decreased precision slightly (AUC=0.85). A score >6 optimizes sensitivity (0.80) and specificity (0.76; AUC=0.81; post-test probability=27%). As shown in the bottom figure, a score >25 reduces false-positives and achieves post-test probability=94% (sensitivity=0.32; specificity=1.00; AUC=0.65).

**Conclusion:** Early withdrawal of care is a difficult decision. The ability to objectively support clinical intuition of futility during triage would be a valuable, practical tool. As all patients scoring <25 survived to 6h, the model and clinical score are high-specificity (low false-positive) ways to inform such decisions in this population. A high clinical score at 1h after arrival may thus signal futility and support limitation of care efforts when clinically indicated. This may be life-saving in mass casualty and other limited-resource situations.



**EARLY TRACHEOSTOMY IN SEVERE TRAUMATIC BRAIN INJURY IS ASSOCIATED WITH DECREASE IN RATE OF VENTILATOR-ASSOCIATED PNEUMONIA: AN ANALYSIS OF TQIP DATA**

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**Introduction:**

Patients with severe traumatic brain injury (sTBI) require intubation to ensure adequate oxygenation, and many progress to tracheostomy. However, tracheostomy timing is controversial. We have previously demonstrated that, in our institution, a lower incidence of ventilator-associated pneumonia in sTBI patients receiving early tracheostomy. Therefore, we sought to extend our results by evaluating the American College of Surgeons Trauma Quality Improvement Program (TQIP) database to determine if an association between tracheostomy timing and development of ventilator-associated pneumonia exists.

**Methods:**

The 2015 data from the TQIP was accessed and 5,662,524 patients were screened for inclusion in our retrospective analysis. Patients included in the analysis were those in whom tracheostomy was performed, had an isolated, sTBI, and those ultimately developing ventilator-associated pneumonia. Patients were matched by age and injury severity score. Fischer's exact and multivariate analyses were used to observe the rate of pneumonia in TBI, the rate of tracheostomy in TBI, and impact of tracheostomy timing on the development of pneumonia. Hospital length of stay, number of days on a ventilator, and ICU length of stay were analyzed using a multivariate analysis.

**Results:**

A total of 4,045 patients met the inclusion criteria for our analysis. Five-hundred-sixty patients received tracheostomy by day 3 of their hospital stay (mean 1.15, SD 1.06) and 3,485 after day 3 (mean 10.44, SD 6.03). There were no statistically significant differences in age, ISS, respiratory rate, or oxygen saturation between the two groups. Early tracheostomy was associated with a rate of pneumonia of 10.23 (CI 7.86-13.02) compared to 21.49 (CI 20.15-22.88) in patients receiving trach after day 3 (OR 2.624, p-value 0.02).

**Conclusion:**

Early tracheostomy was associated with a significant decrease in the rate of pneumonia in patients with severe traumatic brain injury. Future prospective studies are needed to validate the impact of early tracheostomy on patient morbidity and mortality in severe traumatic brain injury.

**SCALPEL OR SHEATH? OUTCOMES COMPARISON BETWEEN PRE-PERITONEAL PELVIC PACKING (PPP) AND ANGIOEMBOLIZATION (AE) FOR DEFINITIVE HEMORRHAGE CONTROL AFTER RESUSCITATIVE ENDOVASCULAR BALLOON OCCLUSION OF THE AORTA (REBOA)**

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**Introduction:** The role of AE and PPP for pelvic hemorrhage control in the era of REBOA has not been well described. Our aim was to investigate outcomes of PPP and AE after REBOA.

**Methods:** Patients who received aortic occlusion (AO) at Zone 3 (distal abdominal aorta) plus PPP and/or AE for blunt pelvic fracture-related hemorrhage at 3 high-volume REBOA centers between February 2013 and December 2018 were identified. Demographics, physiologic variables, and outcomes were reviewed from prospectively collected institutional registries. Patients were divided into 3 groups based on procedures performed: REBOA with PPP only (RPPP), REBOA with angioembolization only (RAE), and REBOA with PPP and AE (RPPPAE).

**Results:** 58 patients underwent REBOA at Zone 3; 37 RPPP, 13 RAE, 8 RPPPAE. Mean age was  $45\pm 16$  years, mean injury severity score (ISS)  $35\pm 13$ , mean SBP pre-AO was  $71\pm 19$ mmHg, and post-AO SBP was  $110\pm 34$ mmHg. Mean time from admission to AO was  $48\pm 41$  mins, and mean duration of AO was  $60\pm 40$ mins. 52% of patients had a pelvic binder, and 59% received external fixation. 62% of RPPP patients and 31% of RAE patients received a 7Fr sheath. Mean blood products transfused within the first 24 hours were  $17\pm 16$  UPRBC,  $13\pm 12$  FFP,  $8\pm 10$  Pk platelets, and 17% of patients received tranexamic acid (TXA). In-hospital mortality was 28%, with the majority of deaths occurring in the intensive care unit (17%). Overall, acute kidney injury (AKI) was the most common systemic complication (28%) followed by acute respiratory distress syndrome/acute lung injury (ARDS/ALI) in 12%, while distal embolism was the most common procedure related complication (12%). Age, ISS, admission SBP, physiology on admission and at the time of AO, response to AO, admission hemoglobin, blood products transfused, and rate of local wound infections were not different between RPPP and RAE groups. Comparing RPPP to RAE groups, duration of AO was significantly lower in the RPPP group ( $45\pm 34$  vs  $81\pm 37$  mins,  $p=0.012$ ), while rates of AKI (14% vs 46%) and distal embolism (8% vs 31%) were higher in the RAE group ( $p=0.015$ ,  $0.04$  respectively). There was no difference in mortality between RPPP (22%) and RAE patients (39%), including on regression analysis controlling for duration of AO and ongoing CPR at the time of AO.

**Conclusion:** Despite a longer duration of AO and higher rates of ongoing CPR at the time of AO in RAE patients, mortality rates are similar whether hemostasis is achieved after REBOA with pelvic packing or angioembolization. RPPP results in significantly lower systemic and local complication rates which may be directly related to shorter durations of AO, size and duration of in-dwelling sheath, or other factors.

## AN ANALYSIS OF OVERTRIAGE AND UNDERTRIAGE BY ADVANCED LIFE SUPPORT TRANSPORT IN A MATURE TRAUMA SYSTEM

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**Introduction:** While issues regarding triage of severely injured trauma patients are well publicized, little information exists concerning the difference between triage rates for patients transported by advanced life support (ALS). We sought to analyze statewide trends in undertriage and overtriage to address this question, hypothesizing that there would be no difference between the undertriage and overtriage rates for ALS compared to BLS over a 13-year period.

**Methods:** All patients submitted to Pennsylvania Trauma Outcomes Study database from 2003-2015 were analyzed. Undertriage (UT) was defined as not calling a trauma alert for patients with an Injury Severity Score (ISS)  $\geq 16$ . Overtriage (OT) was defined as calling a trauma alert for patients with an ISS  $\leq 9$ . Multilevel mixed-effects logistic regression models assessed the adjusted impact of ALS transport on undertriage and overtriage rates while controlling for ISS, age, Glasgow Comma Score (GCS) motor, systolic blood pressure (SBP), and injury type.

**Results:** A total of 462,081 patients met inclusion criteria, of which 116,633 had an ISS  $\geq 16$  and 257,586 had an ISS  $\leq 9$ . Multivariate analysis revealed that patients transported by ALS had a decreased adjusted rate of undertriage (AOR: 0.28  $\pm$  0.005;  $p < 0.001$ ) and an increased adjusted rate of overtriage (AOR: 3.98  $\pm$  0.060;  $p < 0.001$ ) compared to patients transported by BLS.

**Conclusion:** ALS transport can significantly reduce the problem of UT in a trauma system. Unfortunately, it has the negative consequences of increased resource utilization secondary to OT. Further refinements of triage guidelines in the prehospital setting are necessary to achieve both lower UT and also OT.

Variable	Undertriage Model (n=116,633)		Overtriage Model (n=257,586)	
	Adjusted Odds Ratio (95% CI)	p-value	Adjusted Odds Ratio (95% CI)	p-value
ALS	0.28 (0.27-0.29)	<0.001	3.98 (3.87-4.10)	<0.001
Age	1.02 (1.02-1.03)	<0.001	0.98 (0.98-0.99)	<0.001
GCS Motor	1.38 (1.36-1.41)	<0.001	0.61 (0.59-0.62)	<0.001
SBP	1.00 (1.00-1.01)	<0.001	1.00 (1.00-1.01)	<0.001
ISS	0.94 (0.27-0.29)	<0.001	0.98 (0.98-0.99)	<0.001
Injury type (Penetrating)	0.59 (0.55-0.64)	<0.001	2.32 (2.18-2.48)	<0.001
	AUROC:0.78		AUROC:0.76	

**CHANGES IN ERROR PATTERNS IN UNANTICIPATED TRAUMA DEATHS OVER 20 YEARS**

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**Introduction:** A fundamental goal of continuous process improvement programs is to improve the ratio of actual to expected mortality. To study this, we evaluated aspects associated with error associated deaths during two consecutive periods from 1996-2004 (Period 1) and 2005-2014 (Period 2).

**Methods:** All deaths at a level I trauma center with an anticipated probability of death less than 50% and/or identified through process improvement committees were examined. Each death was critically appraised to identify potential error, with subsequent classification of error type, phase, cause, and contributing cognitive processes [JC1] [LL2] . comparison of outcomes made using chi squared test of independence. Demographics assessed for trend only, as Period 1 data only available in median, IQR, which does not permit significance testing.

**Results:** During Period 1, there were a total of 44,401 admissions with 2,594 deaths and 64 deaths (2.5%) associated with error, compared to 60,881 admissions during Period 2 with 2,659 deaths and 77 (2.9%) associated with error. Deaths associated with error occurred in younger and less severely injured patients in Period 1, and were likely to occur during the early phase of care, mostly from lack of hemorrhage control. In Period 2, deaths occurred in older more severely injured patients, and were likely to occur in the later phase of care due to aspiration (*Table*).

**Conclusion:** Despite injured patients being older and more severely injured, error associated deaths due to hemorrhage and early care in the ICU improved over time. Successful implementation of system improvements resolved issues in the early phase of care but shifted deaths to aspiration events during the recovery phase. This study demonstrates that ongoing evaluation is essential for continuous process improvement and alteration in focus of efforts, even in a mature trauma system.

	1996-2004 Period 1	2005-2014 Period 2	1996-2014		
<b>DEMOGRAPHICS</b>					
Age (yr) [IQR]	46 [26-72]	57 [34-78]			
Male:Female (%)	69:31	71:29			
ISS [IQR]	25.5 [20-35]	29 [25-48]			
<b>ERROR PATTERN</b>	<b>n (%)</b>	<b>n (%)</b>	<b>n (%)</b>	<b>X<sup>2</sup></b>	<b>P<sup>*</sup></b>
Management of unstable patients	9 (14)	11 (14)	20 (14)		1.0
Early hemorrhage control and ICU care	18 (28)	10 (13)	28 (20)		0.84
Procedure Related	8 (13)	6 (8)	14 (10)		0.93
Airway management and aspiration	10 (16)	25 (32)	35 (25)		0.84
Prophylaxis	4 (11)	5 (6)	12 (9)		0.92
Missed or delayed diagnosis	7 (11)	12 (16)	19 (13)		0.94

## IMPACT OF THE AFFORDABLE CARE ACT ON POST-DISCHARGE CARE AFTER PELVIC FRACTURE

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**Introduction:** Pelvic fracture is associated with significant morbidity, prolonged recovery and need for post-discharge rehabilitation or skilled nursing care. With the launch of Open Enrollment (OE) in 2014, the Affordable Care Act (ACA) provided insurance coverage to previously uninsured Americans. Little data exists describing the effects of the ACA on access to post-discharge services for patients with commonly disabling traumatic injuries. We hypothesized that implementation of the ACA increased access to post-discharge healthcare facilities for patients with pelvic fracture resulting in decreased early readmission rates.

**Methods:** The Nationwide Readmission Database was queried to identify non-elderly (age < 65) patients with an index admission for traumatic pelvic fracture using ICD-9 or ICD-10 codes. Pre-OE admissions, defined as 2013 Q1-Q3, were compared with post-OE admissions in 2016 Q1-Q3 to evaluate the impact of the ACA OE on discharge disposition, hospital length of stay (LOS), readmission rates at 30/60/90 days post-discharge and mortality. Logistic regression analysis was performed to identify predictors of discharge to a care facility (LTAC + SNF).

**Results:** We identified 18,739 patients (2013 n=8,124 & 2016 n=10,615) with pelvic fractures meeting inclusion criteria. In the post-OE period, Medicaid insurance increased from 17% to 27% (p<0.001) and discharge to a care facility increased from 26% to 31% (p<0.001, see Figure), while there was no difference in hospital LOS between periods. There was no difference in 30- or 60-day readmission rates when comparing pre-OE and post-OE patients across all payers. However, a readmission within 90 days was more common post-OE (10% vs. 12%, p=0.011). There was no difference in mortality during readmission between groups. On multivariate regression analysis, patients discharged to a care facility were more likely to be female (OR 1.13, CI 1.1-1.9) and readmitted within 90 days (OR 1.79, CI 1.59-2.02). Self-pay patients were least likely to be discharged to a care facility (OR 0.29, CI 0.25-0.34), while patients with Medicaid insurance were as likely as those with private insurance to be discharged to a care facility.

**Conclusion:** ACA OE increased access to post-discharge care for patients admitted with pelvic fracture. This increase in access to skilled post-discharge care did not decrease hospital LOS or readmission rates. Further studies are needed to better define the impact of healthcare insurance policies on discharge disposition and outcomes for patients after traumatic injury.

	Pre-OE	Post-OE	p
<b>Payer</b>			
Medicaid	17%	27%	<0.0001
Private Insurance	48%	44%	<0.0001
Self-Pay	12%	8%	<0.0001
<b>Discharge Disposition</b>			
Discharge to Care Facility	26%	31%	<0.001
Routine Discharge Home	50%	47%	<0.001
Home with Home Health Care	20%	18%	<0.001
Mortality	4%	3%	ns

## SEVERE TRAUMATIC BRAIN INJURY: DOES TQIP NEED TO CHANGE ITS DEFINITION?

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**Introduction:** The TQIP report compares outcomes of a trauma center against national data. Although some outcomes are risk stratified for age, severe TBI (sTBI) is not. TQIP defines sTBI as a GCS<9 on admission. We hypothesized that the GCS may have limitations with regards to its ability to predict outcomes with increasing age. As such, we reviewed the outcomes of patients with sTBI, dichotomizing patients into older and younger cohorts.

**Methods:** This retrospective analysis from our trauma database on 540 adult patients presenting to our trauma center from August 2016 to September 2018 with a primary diagnosis of TBI. Data collected included: demographics, mechanism and type of injury, admission GCS(aGCS), AIS, ISS, and hospital mortality. Two groups were created using age=65 as the cutoff for the younger and older groups.

### Results:

Age/aGCS Group	#	Age	aGCS	Brain AIS	ISS	% Mortality
<65, <9	38	39.8±2.4	4.6±0.3	3.9±0.2	24.1±2.3	37
≥65, <9	24	77.8±2.1	4.5±0.4	4.0±0.2	21.1±2.4	63
≥65, <11	33	77.5±1.7	5.9±0.5	3.9±0.2	19.9±2.0	55
≥65, <13	40	78.3±1.5	6.9±0.5	3.9±0.2	19.9±1.7	53
≥65, <15	82	81.2±1.0	10.4±0.5	3.6±0.1	17.4±1.1	30

**Conclusion:** We noted a lack of correlation between aGCS and severity of brain injury as measured by AIS, in our older pts. Therefore, many older patients with significant brain injury are not included in our sTBI report group. Our data confirms that in older pts, an aGCS<9 does not identify patients with significant brain injury or predict death. We expected that in the older patient group mortality would be higher, unexpected was how poor aGCS and AIS were as predictors of death in older pts. In older pts, an aGCS<9 does not adequately capture patients with significant brain injury. We believe that when making sTBI comparisons, either age should be included in the risk stratification, separate categories for sTBI in younger and older populations should be created, or sTBI should be defined by another variable.

**COMPARISON OF FOUR RISK SCALES DESCRIBED FOR GRADING OF POLYTRAUMA PATIENTS - A DATA BASE VALIDATION**

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**Introduction:** Early assessment of the clinical status is crucial for decision making and the surgical treatment strategy in multiply injured patients. Several scales, ranging from expert recommendations to scores developed by data base analyses, were described to differentiate risk categories (stable, borderline, unstable, in extremis), but none was validated. We compared and validated all scales in a separate data base.

**Methods:** Data base from a level I Trauma Center. Inclusion criteria: complete data set (admission, daily for 3 weeks), Injury severity score  $\geq 16$  points; Four scales were tested: Clinical grading scale (CGS; includes acidosis, shock, coagulation, soft tissue injuries), modified clinical grading scale (mCGS; includes CGS with modifications), Polytrauma grading score (PTGS; includes shock, coagulation, ISS), Early appropriate care protocol (EAC; includes acid base changes). These scale cover one or several pathogenetic pathways (coagulopathy, acidosis, hem. shock, soft tissue injuries). Admission values were selected from each scale and the following endpoints were compared: mortality, pneumonia, sepsis, death from hem. shock or multiple organ failure. Statistics: Pearson Chi square, Odds ratios for all endpoints, 95% confidence intervals. Sensitivity and specificity, positive and negative likelihood ratio (PLR), Krippendorff for CGS vs mCGS, R Core Team (2018),  $p < 0.05$ .

**Results:** 3668 severely injured patients, age  $45.8 \pm 20$ , ISS  $28.2 \pm 15.1$ ; mortality 26.8%, pneumonia 19.0%, sepsis 14.9%, death from hem. shock 4.1%, multiple organ failure 1.9%. Our data show distinct different results in the rate of complications, and mortality within all scores. CGS vs mCGS: shift towards more stable patients (Table I). EAC was predictive for hemorrhage, but not for late complications (pneumonia, sepsis) (Table II), while PTGS was most predictive for late complications (PLR pneumonia: 8.4, sepsis: 3.2, MOF: 16.1).

**Conclusion:** PTGS was most predictive for complications during the hospital stay, while EAC only predicted shock. Inclusion of values from several physiological systems (coagulation, hemorrhage, acid-base), as performed in CGS leads to higher predictability of outcomes. The data support development of a validated, easier score than existing ones to cover multiple pathways.

**Table I: Categorization of patients classified according to different scoring systems, complications and outcome parameters.**

		Low Risk				High Risk
		Stable	Borderline	Unstable	In Extremis	
EAC	Pneumonia	19.9%	23.4%	25.0%	26.9%	
	Sepsis	15.9%	15.5%	15.8%	17.4%	
	Mortality	22.5%	24.7%	37.8%	61.2%	
	Death from traumatic hemorrhagic shock	1.2%	3.2%	11.3%	27.6%	
	Death from Multi-Organ Failure	1.7%	1.6%	1.2%	3.5%	
	Death from Traumatic Brain Injury	17.5%	18.4%	22.4%	25.9%	
mCGS	Pneumonia	20	24	16.8%	18	
	Sepsis	16.9%	15.8%	15.8%	17.4%	
	Mortality	21.9%	24.7%	37.8%	60.7%	
	Death from traumatic hemorrhagic shock	1.1%	3.2%	11.3%	27.6%	
	Death from Multi-Organ Failure	2.2%	1.6%	1.2%	11.1%	
	Death from Traumatic Brain Injury	15.9%	18.4%	22.4%	27.6%	
CGS	Pneumonia	21.5%	19.8%	17.3%	14.3%	
	Sepsis	16.0%	15.8%	15.8%	11.4%	
	Mortality	22.5%	25.9%	35.9%	60.0%	
	Death from traumatic hemorrhagic shock	1.7%	3.9%	9.5%	20.0%	
	Death from Multi-Organ Failure	3.1%	2.1%	0.8%	8.6%	
	Death from Traumatic Brain Injury	15.3%	17.0%	22.4%	28.4%	
PTGS	Pneumonia	1740	64	23.7%	0	
	Sepsis	19.1%	21.4%	25.0%	25.0%	
	Mortality	25.4%	35.7%	50%	50%	
	Death from traumatic hemorrhagic shock	3.4%	12.9%	26.6%	0.8%	
	Death from Multi-Organ Failure	1.7%	3.6%	0.8%	0.8%	
	Death from Traumatic Brain Injury	17.8%	14.2%	13.6%	13.6%	

**Table II: Risk of complications according to acid base changes on admission versus additional abnormalities of several pathways indicative of acute hemorrhage, coagulopathy, or severe soft tissue injuries**

Pathologic	OR	CI	p	EAC Low Risk (n=2745)																	
				Mortality			Death within 72			Death from Hemorrhage			Death from MOV			Pneumonia			Sepsis		
				OR	CI	p	OR	CI	p	OR	CI	p	OR	CI	p	OR	CI	p	OR	CI	p
Hemorrhagic shock	12.4%	4.5	3.3-6.2	<0.0001	5.9	4.1-8.6	<0.0001	10.5	3.9-27.9	<0.0001	3.6	1.7-7.9	0.0022	1.5	1.1-2.1	0.018	1.9	1.3-2.6	<0.0001		
Coagulopathy	4.3%	2	1.2-3.3	0.011	3.6	2.1-6.1	<0.0001	5.9	1.9-18.2	0.0088	0.7	0.1-5.7	1	0.7	0.4-1.4	0.37	1.2	0.7-2.1	0.53		
Soft Tissue injuries	64.3%	0.41	0.3-0.5	<0.0001	0.41	0.3-0.5	<0.0001	ALL	NA	<0.0001	1.3	0.7-2.5	0.44	1.3	1.1-1.6	0.02	1.5	1.2-1.9	<0.0001		

**IMPROVED PATIENT SELECTION RESULTS IN INCREASED SURVIVAL RATES AFTER EMERGENCY DEPARTMENT THORACOTOMY - A NATIONAL TRAUMA DATA BANK ANALYSIS**

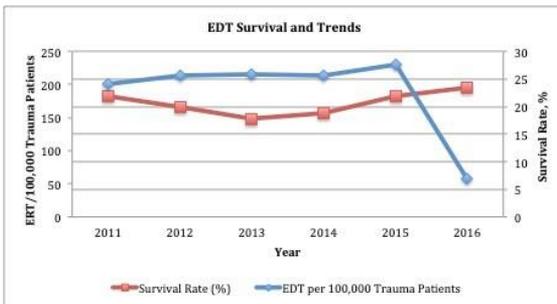
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**Introduction:** An emergency department thoracotomy (EDT) can be a life-saving intervention in trauma patients presenting *in extremis*. Prior to 2012, there was a paucity of evidence-based EDT guidance directing its utilization. The 2012 Western Trauma Association (WTA) guidelines recommend EDT utilization based on pre-hospital CPR time and mechanism of injury (blunt: < 10 minutes and penetrating: < 15 minutes). We hypothesized the WTA guidelines would result in fewer EDTs performed and an increased survival to hospital discharge.

**Methods:** Data was abstracted from the National Trauma Data Bank (2011-2016). Adult trauma patients (age ≥ 18) with an Injury Severity Score (ISS) ≥ 16, undergoing an EDT (ICD-9 code: 34.02) were included. Inter-facility transfer patients were excluded. An EDT was defined as a procedure occurring within the first 60 minutes of the emergency department evaluation. Patient demographics, initial ED vital signs, and ED and hospital outcomes were recorded. Patients were grouped by mechanism of injury. Inter-group and intra-year comparisons were performed using chi-squared analysis and ANOVA with Benjamini-Hochberg corrections. Significance was p ≤ 0.05.

**Results:** 6022 patients (ED survival: 65% (n=3935), ED mortality: 34.6% (n=2087)) were included. Survival was associated with a significantly increased age (35.9±15 y.o. vs. 33.8 ±13 y.o.), heart rate (105±38 beats/min. vs. 50±58 beats/min.), SBP (100±47 mmHg vs. 46 ±58 mmHg) and GCS (13 (IQR:3,15) vs. 3 (IQR:3,3), (p < 0.001). Survival to hospital discharge was associated with a significantly lower ISS (25 (IQR:17,33) vs. 29 (IQR:20,43), p<0.001). After 2012, the EDT utilization rate (procedures/100,000 trauma patients) significantly decreased (2012: n=213; 2016: n=58, p<0.001). A significant increase in survival to hospital discharge was not seen, (2012: 21.8% (n=213); 2016: 23.4% (n=82), p=0.386). A subgroup analysis demonstrated blunt trauma patients had a significant increase in survival to hospital discharge (2012: 6% (n=17), 2016: 16% (n=15), p<0.05). This significant difference was not seen in penetrating trauma patients (2012: 25.6% (n=206), 2016: 27.5% (n=58), p=0.104).

**Conclusion:** The 2012 WTA EDT guidelines may have contributed to improved patient selection and accounted for decreased EDT utilization rates and increased blunt trauma patient survival.



## **THE IMPACT OF A STREAMLINED TRAUMA-FOCUSED SMARTPHONE APPLICATION ON PROTOCOL COMPLIANCE AND DELIVERY OF EVIDENCE-BASED TRAUMA CARE**

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**Introduction:** In November 2015, we created an institution-specific mobile app to provide rapid access to trauma policies and protocols. Beta testing indicated that the app was cumbersome and infrequently used. In June 2018, the app was redesigned to feature protocol infographics and treatment algorithms available offline, eliminating the need for internet access and scrolling through links to web pages and lengthy text fields to find information. Prior to introducing the new app into daily use, residents, nurse practitioners (NPs), and attending trauma surgeons were formally educated on app content, use, and the method for adding the app to mobile devices. We sought to evaluate the efficacy of the new version of the app to facilitate access to trauma-specific knowledge.

**Methods:** This was a prospective, randomized study of the effectiveness of a streamlined, institution-specific trauma app. Participants included general surgery residents, NPs, and attending trauma surgeons. The primary exposure of interest was access to the app during a multiple-choice exam consisting of questions regarding management of trauma scenarios, and participants were randomized 1:1 to have or not have app access during the exam. The primary outcomes measured were time to exam completion and number of questions answered correctly. Results were further compared to our historical cohort from testing of the 2015 version to assess improvement.

**Results:** 30 participants tested the current version of the app: 15 with app access to complete the quiz and 15 without app access. The group with access scored more accurately on the quiz compared to the group without access (70% vs 50%,  $p=0.002$ ), and to the group that had access during the 2015 study ( $n=15$ , 55% correct,  $p=0.037$ ). Access to the current app version led to an increased amount of time for exam completion, with the access group taking longer than those without access in the current study (11:21 vs 5:39,  $p<0.001$ ) and those with access in the historical cohort (9:09, NS).

**Conclusion:** The newest version of our institution-specific trauma app led to improved ability to apply knowledge correctly, but continued to do so at the expense of time. Further work is needed to optimize this tool, but it continues to show promise as an inexpensive, highly reproducible tool to aid trauma centers in applying evidence-based knowledge at the point of care.