Session: Session I: Papers 1-8 Plenary
Paper 1: 8:00-8:20 am

ACS-COT VERIFICATION LEVEL AFFECTS TRAUMA CENTER MANAGEMENT OF PELVIC RING INJURIES AND PATIENT MORTALITY

Bryant Oliphant MBA,MD, Christopher Tignanelli MD, Lena M. Napolitano* MD, James A. Goulet MD, Mark R. Hemmila* MD, University of Michigan

Invited Discussant: Todd Costantini, MD

Introduction: Pelvic ring fractures represent a complex injury that requires specific resources and clinical expertise for optimal trauma patient management. We examined the impact of treatment variability for this type of injury at Level 1 and 2 trauma centers on patient outcomes.

Methods: Trauma quality collaborative data (2011-2017) were analyzed. This includes data from 29 ACS_COT verified Level 1 and Level 2 trauma centers. Inclusion criteria were adult patients (≥16 years), ISS ≥ 5, blunt injury, and evidence of a partially stable or unstable pelvic ring fracture which was classified via the Abbreviated Injury Scale version 2005 (AIS2005). Patients directly admitted, transferred out for definitive care, penetrating trauma or with no signs of life were excluded. Propensity score matching was used to create 1:1 matched cohorts of patients treated at Level 1 or 2 trauma centers. Trauma center verification level was the exposure variable used to compare management strategies, resource utilization, and in-hospital mortality in univariate analysis.

Results: We selected 1220 well matched patients, from 1,768 total patients, using propensity score methods (610 Level 1 and 610 Level 2 cohort). There were no significant baseline characteristic differences noted between the groups Patients with pelvic ring fractures treated at Level 2 centers had significantly increased mortality (Table). These patients were also less likely to receive interventional angiography, undergo complicated definitive orthopaedic operative treatment, and to be admitted to the ICU. Level 2 centers were more likely to admit their patients to stepdown type units. The failure to rescue rate was lower in patients in an ICU than in those in a non-ICU setting.

Conclusions: Admission with a partially-stable or unstable pelvic ring injury to a Level 2 trauma center is associated with increased mortality. Level 2 trauma centers had significantly less utilization of advanced treatment modalities. This variation in clinical practice highlights processes to emphasize in the appropriate treatment of these critically ill patients.

Outcome % (n)	Level 1 Trauma Center	Level 2 Trauma Center	p-value
Mortality	7.7 (47)	11.6 (71)	0.02
Process % (n)			
Angiography	11 (66)	6 (39)	0.009
ORIF/CRPF	42 (256)	32 (197)	0.002
ICU admission	52 (269)	45 (218)	0.02
Stepdown admission	6.8 (35)	19 (93)	<0.001
ORIF, Open Reduction Internal Fixation; CRPF, Closed Reduction Percutaneous Fixation			

Session: Session I: Papers 1-8 Plenary
Paper 2: 8:20-8:40 am

KETAMINE INFUSION FOR PAIN CONTROL IN ADULT PATIENTS WITH MULTIPLE RIB FRACTURES: RESULTS OF A RANDOMIZED CONTROLLED TRIAL

Thomas Carver* MD, Nathan Kugler MD, Janelle Juul PharmD, William Peppard PharmD, Lewis Somberg MD, Karin Madsen MD, Aniko Szabo Ph.D., Ziyan Yin MS, Jasmeet Paul* MD, Medical College of Wisconsin

Invited Discussant: David Spain, MD

Introduction: Rib fractures occur in up to 40% of trauma patients with pulmonary complications increasing the associated mortality. Opiate-based pain regimens remain the cornerstone of rib fracture management; however, concerns around opioids have fostered interest in alternative analgesics. Ketamine is an attractive analgesic but evidence to support the use of ketamine within the trauma population is lacking.

Methods: A prospective, randomized, double-blind placebo-controlled trial of non-elderly adult patients with at least three rib fractures admitted to a Level 1 trauma center was conducted. Patients over 64 years of age, GCS less than 13, or chronic opiate users were excluded. Patients were treated using a standardized multi-modal pain management protocol. Those randomized to the experimental arm received ketamine at a rate of 2.5 mcg/kg/min within 12-hours of arrival. The placebo cohort received an equivalent rate of normal saline and all infusions were continued for 48-hours. The primary outcome of the study was reduction in numeric pain score (NPS) in the first 24 hours after infusion initiation. Secondary outcomes include oral morphine equivalent (OME) utilization, intensive care unit and overall length of stay, epidural placement rate, pulmonary complications, and adverse events related to ketamine.

Results: Ninety-one patients were enrolled with 45 (49%) randomized to the experimental arm. Experimental and placebo groups were similar in makeup. Overall, 74.7% of patients were male, had a median age of 49 years, and an injury severity score (ISS) of 14. Motor vehicle collision was the most common (45.7%) mechanism of injury. Ketamine infusion was not associated with a significant reduction in 24-hour NPS or OME totals. Subgroup analysis of 45 severely injured patients (ISS >15) demonstrated ketamine infusion was associated with a significant reduction in OME utilization during the first 24-hours (35.7 vs. 68, p=0.03), 24-48 hours (64.2 vs 96, p=0.03), and overall (152.1 vs 198, p=0.048). There was no difference in adverse events between groups. No other secondary outcome differences were observed.

Conclusion: This is the first prospective randomized double-blind, placebo-controlled trial of ketamine in patients with rib fractures. While ketamine infusions failed to decrease NPS or OME within the overall cohort, a decrease in opioid use among severely injured patients was observed. While further studies are necessary to expand on these results, ketamine infusions appear to be a useful adjunct among severely injured trauma patients.

Session: Session I: Papers 1-8 Plenary
Paper 3: 8:40-9:00 am

CLEARING THE CERVICAL SPINE FOR PATIENTS WITH DISTRACTING INJURIES: AN AAST MULTI-INSTITUTIONAL TRIAL

Sean Liebscher Hannah C. Reiser MD, Michael Anstadt MD, Patrick Bosarge* MD, Jacob Quick MD, Stephen Barnes* MD, LaDonna Allen RN, Nicholas Morin MD, Mario Gomez MD, Abid Khan MD, Thomas Schroeppel* MD, Heitor Consani MD, Shannon Carroll MD, Richard P. Gonzalez* MD, Loyola University Medical Center

Invited Discussant: Kenji Inaba, MD

Introduction: Previous single institution studies have shown that clinical examination of the cervical spine (c-spine) is sensitive for clearance of the c-spine in blunt trauma patients with distracting injuries. Despite an unclear definition and a paucity of data defining distracting injury in the context of c-spine clearance, ATLS guidelines and most trauma centers adhere to the notion that distracting injuries adversely affect the sensitivity of c-spine clinical examination for identification of clinically significant injury. A prospective AAST sponsored multi-institutional trial was performed to assess the sensitivity of clinical examination screening of the c-spine in awake and alert blunt trauma patients with distracting injuries.

Methods: Seven Level 1 trauma centers participated in the study. During the 42-month period from July 2014 to December 2017, blunt trauma patients older than 18 years were prospectively evaluated with a standard cervical spine examination protocol. Awake and alert patients with a Glasgow Coma Score (GCS) $\geq$14 underwent clinical examination of the c-spine. Clinical examination was performed regardless of the presence of distracting injuries. Patients without complaints of neck pain, tenderness or pain on range of motion were considered to have a negative c-spine clinical examination. All patients with and without distracting injuries were assessed. All patients with positive or negative c-spine clinical examination underwent computerized tomographic (CT) scan of the entire c-spine. Clinical examination findings were documented prior to CT scan. Distracting injuries were classified into three anatomic regions: head injuries, torso injuries and long bone fractures.

Results: During the 42-month study period, 2929 patients were entered. 70% of the patients (2,058 patients) were diagnosed with at least one distracting injury. Two hundred and twenty-three (7.6%) patients in the study population were diagnosed with a c-spine injury. One hundred and thirty-six patients with distracting injuries were diagnosed with c-spine injury, 14 (10.3%) of which were missed by clinical examination. Eighty-seven patients without distracting injury were diagnosed with c-spine injury of which 11 (12.6%) were missed by clinical examination ($p = 0.58$). Only one injury missed by clinical examination underwent surgical intervention.

Conclusion: In the awake and alert blunt trauma patient with distracting injuries, clinical examination is a sensitive screening method for significant cervical spine injury. Distracting injuries do not appear to affect the sensitivity of c-spine clinical examination. As with patients who do not have distracting injuries, radiological assessment is unnecessary for safe clearance of the asymptomatic cervical spine in awake and alert blunt trauma patients with distracting injuries. These findings suggest potential reduction of both healthcare cost and patient radiation exposure.

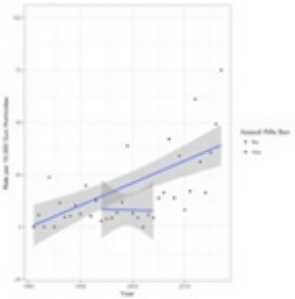
Session: Session I: Papers 1-8 Plenary
Paper 4: 9:00-9:20 am

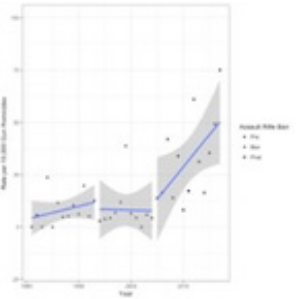
THE EFFECTIVENESS OF THE 1994-2004 FEDERAL ASSAULT WEAPONS BAN IN CONTROLLING MASS SHOOTING DEATHS: ANALYSIS OF OPEN-SOURCE DATA

Charles DiMaggio MPH,Ph.D., Cherisse Berry* MD, Marko Bukur* MD, Michael Klein* MD, Manish Tandon* MD, Spiros Frangos* MD,MPH, New York University Langone Medical Center

Invited Discussant: Ernest Moore, MD

Introduction: The Federal Assault Weapons Ban (AWB) of 1994 made the manufacture and use by civilians of a defined set of automatic and semi-automatic weapons and large capacity magazines illegal. The ban expired in 2004 and was not renewed. A federal assault weapons ban has been proposed as a way to prevent and control mass shootings in the United States; thus, the period from 1994 to 2004 serves as a natural experiment to assess the effectiveness of this policy intervention.
Methods: Mass shooting data from 1982 to 2017 were obtained from a documented, referenced, open-source set of data based on news reports. These data have been cited and used in a number of prior studies. The yearly rates of mass shooting fatalities per 10,000 gun homicide deaths in the United States were calculated. To help control for secular trends in population, we chose to normalize by gun homicides, gun ownership and violence. The period from 1994 to 2004 was compared to the non-ban periods using a linear regression model with an indicator variable for the ban period and a year variable to control for trend. The analysis was repeated for the subgroup of data restricted to incidents in which an assault-type weapon was explicitly noted.
Results: Between 1982 and 2017, 97 shooting incidents involving 4 or more victims resulted in 816 deaths among 2,091 total victim injuries, for an overall case-fatality ratio of 39.0% (95% CI 36.9, 41.1). On average, each year an additional gun-related death in the United States was due to a mass shooting (coefficient for year = 1.01, p = 0.0001), with increment in year alone capturing over a third of the overall variance in the data (Adjusted R-squared = 0.3745). This strong underlying linear trend reversed during the years in which the AWB was in effect. After the ban expired, there was a dramatic increase in the rate of mass shooting fatalities. (Figures 1 and 2) In a linear regression model controlling for yearly trend, the federal ban period was associated with a statistically significant 12 fewer mass shooting related deaths per 10,000 gun homicides (p = 0.02). The model indicated that year and the federal ban alone accounted for nearly half of all the variation in the data (Adjusted R-squared = 0.4549). A similar pattern was evident in data restricted to those incidents characterized as involving assault weapons.
Conclusion: The federal assault weapons ban of 1994 to 2014 was effective in preventing and controlling mass-shooting related homicides.





Session: Session I: Papers 1-8 Plenary
Paper 5: 9:20-9:40 am

NATIONWIDE ANALYSIS OF RESUSCITATIVE ENDOVASCULAR BALLOON OCCLUSION OF THE AORTA (REBOA) IN CIVILIAN TRAUMA.

Bellal Joseph* MD, Muhammad Zeeshan MD, Mohammad Hamidi MD, Narong Kulvatunyou* MD, Joseph Sakran* MD, Terence O'Keeffe* MD, Peter Rhee* MD, University of Arizona - Tucson

Invited Discussant: Megan Brenner, MD, MSc

Introduction: The need for improved methods of hemorrhage control and resuscitation along with the translation of endovascular specialty skills has resulted in reappraisal of resuscitative endovascular balloon occlusion of the aorta (REBOA). The aim of our study was to evaluate the outcomes in trauma patients after REBOA placement. We hypothesized that REBOA is associated with improved survival.
Methods: We performed a 2-year (2015-2016) review of TQIP and identified trauma patients who underwent REBOA placement and matched them with a similar cohort of patients (No-REBOA). Both groups were matched in a 1:2 ratio using propensity score matching for demographics, vitals (prehospital and ED SBP, HR, GCS), mechanism of injury, ISS, h-AIS, c-AIS, Pelvic fractures (intact, incompletely disrupted and completely disrupted pelvic ring), lower extremity vascular injuries and fractures, number and grades of intra-abdominal solid organ injured (liver, splenic, kidney injuries). Outcomes were rates of complications and mortality.
Results: Of the 593818 trauma patients, 420 patients (REBOA: 140; No-REBOA: 280) were matched. Mean age was 44±20 years, ISS was 29 [18-39], 74% were males and 92% patients had blunt mechanism of injury. Overall rate of complications and mortality were 7.4% and 24.5% respectively. There was no difference in 4-hours or 24-hours blood transfusion, and hospital or ICU length of stay as shown in Table 1. Mortality rate was higher in the REBOA Group as compared to the No-REBOA group (36% vs 19%, p=0.01). Patients who underwent REBOA placement were also more likely to develop AKI (10.7% vs 3.2%, p=0.02) and more likely to undergo lower extremity amputation (4.5% vs 0.7%, p=0.04). On sub-analysis using logistic regression based on SBP, REBOA was associated with worse mortality in patients with SBP 80-110 group (OR: 4.67[1.35-15.42], p=0.03) or in the SBP<80 group (OR: 2.51[1.16-14.41], p=0.03).
Conclusion: In a matched cohort of severely injured patients REBOA placement as compared to standard therapy was associated with higher rates of complications and mortality. Further clinical trials are required to define the trauma patients that may benefit from REBOA.

Table 1. Outcomes

Variables	REBOA (n=140)	No REBOA (n=280)	*P-value*
4-Hours Transfusion			
pRBC, units, median[IQR]	6[3-8]	7 [3-9]	0.14
Platelets, units median[IQR]	4 [3-9]	4 [3-8]	0.13
Plasma, units, median[IQR]	3[2-5]	3 [2-6]	0.17
24-Hours Transfusion			
pRBC, units, median[IQR]	9 [5-20]	10 [4-21]	0.21
Platelets, units median[IQR]	7 [3-13]	8 [3-12]	0.12
Plasma, units, median[IQR]	9 [6-20]	10 [7-20]	0.11
Hospital-LOS, d, median[IQR]	10 [1-20]	10 [5-22]	0.21
ICU-LOS, d, median[IQR]	5 [2-14]	6 [3-15]	0.19
Complications, % (n)			
AKI	10.7% (15)	3.2% (9)	0.02
Amputation of lower limb	4.5% (5)	0.7% (2)	0.04
Overall mortality, % (n)	36% (50)	19% (53)	0.01
ED mortality	2.9% (4)	1.8% (5)	0.35
24-Hours mortality	26% (37)	12% (33)	0.01
After 24-Hospital mortality	7.1% (9)	5.2% (15)	0.21

pRBC = Packed Red blood cells, LOS = Length of stay, ICU = Intensive care unit, AKI = Acute kidney injury, SD = Standard deviation, IQR = Interquartile range

Session: Session I: Papers 1-8 Plenary
Paper 6: 9:40-10:00 am

MORTALITY OUTLIER HOSPITALS AND IMPROVING THE QUALITY OF CARE IN EMERGENCY GENERAL SURGERY

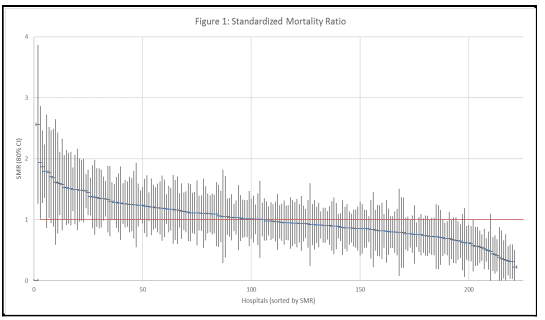
Robert D. Becher MD, MS, Michael P. DeWane MD,MPH, Nitin Sukumar MS, Marilyn J. Stolar Ph.D., Thomas M. Gill MD, Adrian A. Maung* MD, Kevin M. Schuster* MD,MPH, Kimberly A. Davis* MBA,MD, Yale School of Medicine

Invited Discussant: Shahid Shafi, MD, MPH, MBA

Introduction: Expected performance rates for various outcome metrics are a hallmark of hospital quality indicators used by AHRQ, CMS, and NQF. The identification of outlier hospitals with above- and below-expected mortality for emergency general surgery (EGS) operations is therefore of great value for EGS quality improvement initiatives. The aim of this study was to determine hospital variation in morality after EGS operations, and compare hospital-level characteristics between outlier hospitals.

Methods: Using data from the California State Inpatient Database (2010-2011), we identified patients who underwent one of eight common EGS operations. Expected mortality was obtained from a Bayesian model, adjusting for both patient- and hospital-level variables. A hospital-level standardized mortality ratio (SMR) was constructed (ratio of observed to expected in-hospital deaths). Only hospitals performing ≥3 of each operation were included. High-SMR (>1.0) and low-SMR (<1.0) "outliers" were compared; outliers had 80% confidence interval that did not cross SMR=1.0.

Results: There were 140,333 patients included from 220 hospitals. SMR (Figure 1) varied from a high of 2.56 (mortality 156% higher than expected) to a low of 0.22 (mortality 78% lower than expected). A total of 12 hospitals were high-SMR outliers, and 28 were low-SMR outliers. Patient-level characteristics (age, gender, comorbidities) were similar in both outlier groups. Standardized mortality was over 3 times worse in the high-SMR outliers compared to the low-SMR outliers (1.68 vs 0.51; p<0.001). Hospital-level characteristics were equivalent in each outlier group, including percentage of verified trauma centers, high-tech hospitals, teaching hospitals, average hospital volume, and small hospitals (<100 beds).



Conclusion: There exists significant hospital variation in standardized mortality after EGS operations. High-SMR outliers have significant excess mortality, while low-SMR outliers have superior EGS survival. Common hospital-level characteristics do not explain the wide gap between under- and over-performing outlier institutions. These findings suggest that SMR can help guide assessment of hospital EGS performance; further research is essential to identify and define the hospital processes of care which translate into optimal EGS outcomes.

Session: Session I: Papers 1-8 Plenary
Paper 7: 10:00-10:20 am

VARIATION IN MISSED READMISSIONS AFTER APPENDICITIS: NATIONAL ANALYSIS INCLUDING READMISSION TO A DIFFERENT HOSPITAL

Rishi Rattan MD, Joshua Parreco MD, Georgia Vasileiou MD, Daniel D. Yeh* MD, Sarah A. Eidelson MD, Joann Gold BS, Tanya L. Zakrison* MD,MPH, Nicholas Namias* MBA,MD, University of Miami

Invited Discussant: Christopher Dente, MD

Introduction: Accurate tracking of outcomes after treatment for acute appendicitis (AA) is essential. There are no national studies examining readmission after AA that include readmissions to different hospitals. The objective of this study was to determine the national rate of and risk factors for readmission after AA.

Methods: The Nationwide Readmissions Database (2010-2014) was queried for non-elective adult AA discharges. Outcomes included 30-day (d) and 1-year (yr) AA-related readmission requiring percutaneous drainage (PD) or appendectomy to index and different hospitals. Multivariate logistic regression identified risk factors.

Results: For the 1,194,014 included patients, initial management included: appendectomy (91.9%, n=1,097,835), non-operative management (NOM) (6.8%, n=81,652), and PD (1.2%, n=14,526). 30-d and 1-yr readmission for AA was 0.4% (n=4,936) and 0.7% (n=8,456) and of those, 12.6% (n=623) and 13.3% (n=1,122) were to a different hospital, respectively. Patients readmitted within 30-d and 1-yr underwent appendectomy in 34.4% (n=1,699) and 51.2% (n=4,325), and PD in 16.1% (n=795) and 11.7% (n=990) of cases, respectively. Patients readmitted to a different hospital had higher rates of appendectomy at 30-d (47.8% vs 34.4%, p<0.0001) and 1-yr (57.4% vs 51.2%, p=0.0001). 30-d and 1-yr AA-related readmission rates in the subgroup treated initially with NOM was 3.9% (n=3,173) and 6.9% (n=5,642) and of those, 14.1% (n=447) and 14.4% (n=811) were to a different hospital, respectively. Patients readmitted within 30-d and 1-yr after NOM underwent appendectomy in 38.5% (n=1,223) and 56.0% (n=3,157) and PD in 11.5% (n=336) and 8.2% (n=465) of cases, respectively. At 30-d and 1-yr, 20.6% (n=252) and 16.2% (n=513) of patients initially treated with NOM and readmitted with AA underwent an appendectomy at a different hospital, respectively. Risk factors for and protective factors against 1-yr AA-related readmission included: NOM (OR 64.73 [60.74-68.99], p<0.0001), leaving against medical advice (AMA) (OR 2.02 [1.70-2.39, p<0.0001), Medicaid (OR 1.26 [1.19-1.34], p<0.0001), diabetes (OR 1.24 [1.13-1.37], p<0.0001), and discharge to skilled nursing (OR 0.59 [0.51-0.69], p<0.0001). Risk factors for and protective factors against 1-yr AA-related readmission to a different hospital included: NOM (1.21 [1.00-1.46, p=0.052), leaving AMA (OR 4.51 [3.23-6.29], p<0.0001), drug abuse (OR 2.00 [1.34-2.99], p<0.0001), diabetes (OR 1.75 [1.06-2.89], p=0.03), for-profit hospital index admission (OR 1.56 [1.24-1.95], p<0.0001), age ≥65 years (OR 1.44 [1.10-1.88], p<0.0001), and metropolitan teaching hospital index admission (OR 0.64 [0.55-0.74], p<0.0001).

Conclusion: One in eight patients readmitted with AA and one in seven failures of NOM are missed by existing quality measures due to different hospital readmission. Current benchmarking is inaccurate and results in reporting more favorable for for-profit hospitals and less favorable for metropolitan teaching hospitals. Recurrence rates after NOM in the United States are lower than those reported in European clinical trials. Patients experiencing fragmentation of care have higher rates of operative intervention. Risk factors for readmission to a different hospital are distinct, suggesting analyses including only same hospital readmissions miss a unique subpopulation.

Session: Session I: Papers 1-8 Plenary
Paper 8: 10:20-10:40 am

MANAGEMENT OF ADHESIVE SMALL BOWEL OBSTRUCTION: A DISTINCT PARADIGM SHIFT IN THE UNITED STATES

Kazuhide Matsushima MD, Andrew Sabour BS, Caroline Park MD,MPH, Aaron Strumwasser MD, Kenji Inaba* MD, Demetrios Demetriades* MD,Ph.D., LAC+USC Medical Center

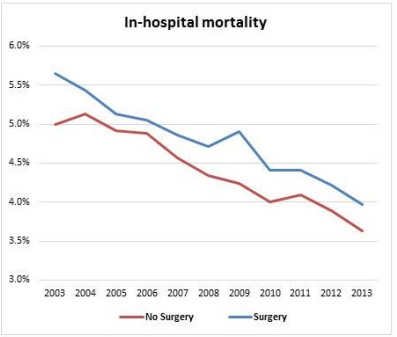
Invited Discussant: Martin Zielinski, MD

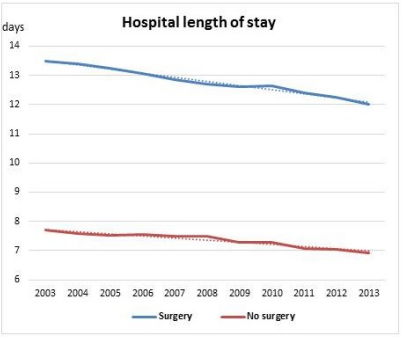
Introduction: Recent studies showed that early operative intervention in patients who fail non-operative management of adhesive small bowel obstruction (SBO) is associated with improved outcomes. The purpose of this study was to determine the trend in practice pattern and outcomes of patients with adhesive SBO in the United States.

Methods: Data from the Nationwide Inpatient Sample data (2003-2013) were extracted for analysis, and included patients (age ≥18 years) who were admitted with primary diagnosis codes consistent with adhesive SBO. We analyzed the data to examine changes in mortality and hospital length of stay (HLOS) in addition to any trends in rate and timing of operative intervention.

Results: During the study period, 1,930,289 patients were admitted with the diagnosis of adhesive SBO. While the rate of operative intervention declined (46.1 to 42.1%, p=0.0025), the timing between admission and operative intervention was significantly shortened (3.09 to 2.49 days, p<0.0001). In-hospital mortality rate decreased significantly (5.29 to 3.77%, p<0.0001). In the multiple logistic regression analysis, the relative risk of mortality decreased by 5.7% per year (OR: 0.943, 95% CI: 0.936-0.949, p<0.0001). HLOS decreased from 10.4 days to 9.06 days (P<0.0001).

Conclusion: Over the last decade, fewer patients with adhesive SBO were managed operatively, whereas those requiring an operation underwent one earlier in their hospitalization. Although further studies are warranted, our results suggest that recent changes in practice pattern may have contributed to improved outcomes.





Session: Session IV: Papers 9-16 Trauma Systems
Paper 9: 2:15-2:35 pm

SHOULD THEY STAY OR SHOULD THEY GO? WHO BENEFITS FROM INTERFACILITY TRANSFER TO A HIGHER LEVEL TRAUMA CENTER FOLLOWING INITIAL PRESENTATION FROM A LOWER LEVEL TRAUMA CENTER

Christopher J. Tignanelli MD, Tessa Adzemovic BS, Thomas Murray Ph.D., Julie Ottosen MD, Patei Iyegha MD, Lena M. Napolitano* MD, Mark R. Hemmila* MD, Krishnan Raghavendran* MD, Pauline K. Park* MD, Jonathan Gipson MD, University of Minnesota Dept of Surgery

Invited Discussant: Jason Sperry, MD, MPH

Introduction: The interfacility transfer of injured patients from verified or designated level 3 or 4 trauma centers to a level 1 or 2 center has been associated with improved outcomes. However, a drawback to transfer is significant rates of secondary over-triage and unnecessary resource utilization. Little data are available describing which patients derive benefit from transfer. In this study, we investigate specific injury patterns and physiologic/demographic parameters associated with improved survival following interfacility transfer to level 1 or 2 trauma centers after initial presentation at a lower level facility.

Methods: Data from the National Trauma Data Bank covering 2007 to 2014 was utilized. Inclusion criteria were adults (≥16 years). Patients with Injury Severity Score (ISS) ≤ 10, those who arrived with no signs of life, or with missing data were excluded. Patients were divided into two categories: those who were initially evaluated at and subsequently admitted to a level 3-4 trauma center verses those who were transferred from a prior hospital's Emergency Department (ED) to the ED of a level 1-2 trauma center for evaluation and treatment. Multilevel mixed effects logistic regression models were fit to the data to estimate the effect of transfer to a level 1-2 trauma center on all-cause in-hospital mortality for 16 injury patterns. Injury patterns included: any traumatic brain injury (TBI), severe (Glasgow Coma Scale (GCS) < 9) TBI, TBI with intracranial bleed, TBI with no bleed and GCS > 13, any C-spine injury, C-spine injury with spinal cord injury, all solid organ injuries, grade 3 or higher solid organ injury, bowel or pancreas injury, femur fracture, all pelvis fractures, complex pelvic fracture, any rib fracture, greater than 3 rib fractures, greater than 6 rib fractures, hemo/pneumothorax. Additional physiologic and demographic parameters were also evaluated. Each model adjusted for demographic parameters, mechanism (blunt/penetrating), injury severity parameters (ISS, TMPM-ICD-9 predicted mortality, ED vitals, GCS, assisted respirations, blood alcohol content), medical comorbidities, and hospital level random effects.

Results: 253,013 patients were included in this study. 14,405 (5.7%), were admitted to level 3-4 trauma centers and 238,608 (94.3%) were transferred into to a level 1-2 trauma center. The mean ISS was 17.8 (SD: 6.8) for patients admitted to a level 3-4 trauma center verses 20.0 (SD: 8.1) for patients transferred into a level 1-2 trauma center. Compared to the patients who were admitted to a level 3-4 trauma center, patients who were transferred to level 1-2 trauma centers had reduced mortality (OR 0.74, 95% CI 0.63 – 0.88, p < 0.001). Of the 16 injury patterns, physiologic, and demographic parameters evaluated, 3 injury patterns and 4 parameters were associated with reduced mortality, i.e. estimated OR < 1 (Table). Of the patients transferred to a level 1-2 trauma center, 56,432 (23.7%) did not have any of these 7 minimum elements. The cumulative mortality at level 1-2 centers for transferred patients without any elements was 0.5% compared with 11.2% for patients with one or more element present. Patients admitted to level 3-4 trauma centers without any elements present did not have increased mortality (0.3%).

Conclusion: Interfacility transfer of patients presenting to lower level trauma centers was associated with a survival benefit for specific cohorts of patients. Patients with TBI with intracranial bleed, GCS < 13, grade 3 or higher solid organ injury, multiple rib fractures, age ≥ 65, respiratory distress, or shock benefited from transfer. These data suggest that implementation of minimum evidence-based criteria for interfacility trauma transfer to higher level care would promote appropriate trauma triage, reduce overall resource utilization, and save lives.

Injury Pattern	**OR**	**95% CI**	**P value**
Severe TBI (GCS < 9)	0.50	0.37 - 0.68	< 0.001
TBI with any intracranial bleed	0.61	0.49 - 0.75	< 0.001
TBI with no intracranial bleed and GCS > 13	0.96	0.58 – 1.6	0.9
Grade 3+ solid organ injury	0.58	0.35 - 0.96	0.03
Greater than 6 rib fractures	0.66	0.43 - 1.0	0.056
Physiologic/Demographic Parameters			
Elderly (Age ≥ 65)	0.77	0.64 - 0.93	0.006
GCS < 13	0.53	0.42 - 0.68	< 0.001
Respiratory Distress (RR < 10, > 29)	0.69	0.47- 1.0	0.055
Shock Index > 0.8	0.64	0.49 - 0.83	0.001

Session: Session IV: Papers 9-16 Trauma Systems
Paper 10: 2:35-2:55 pm

DEVELOPMENT OF A GIS-BASED APPROACH FOR THE QUANTITATIVE ANALYSIS OF TRAUMA CENTER ACCESS

Paige Xu BS, Lauren E. Mount MD, Reed Huegerich MCRP, AICP, Robert J. Winchell* MD, Weill Cornell Medicine

Invited Discussant: Frederick Rogers, MD

Introduction: Decisions around trauma center (TC) designation have become contentious in many parts of the country. The problem is compounded by the fact that there is no consensus as to the ideal number and geographic distribution of TC in a region, and no reliable, objective metrics to assess the effect of changes in structure on system capacity, access, and impact on existing TC. We aim to develop a set of quantitative metrics for population access within a regional network, using publicly available data and geographic information systems (GIS)-based methodology. We hypothesize that geospatial analysis can provide a reproducible approach to transparently and quantitatively assess potential changes in trauma system structure.

Methods: Based on data availability and relative isolation, the area near Rochester, NY, was chosen for initial model development. Network analyst tools in ArcGIS Desktop 10.4 were used for geospatial calculations. Population coverage was estimated using US census tracts, with tract population located at the geographic centroid. Drive time polygons were created in 10-minute increments around target TC, and the population covered was estimated by summing the census tract centroids within the drive time area. Transport time was estimated by calculating drive time from each census tract centroid to the nearest TC. The existing TC model includes the single designated TC in the region. Model 1, with 1 additional TC, and model 2, with 2 additional TC, were created by selecting additional candidate centers from existing acute care facilities in the region in order to maximize population covered within 60 minutes of travel, and population covered in 10-minute travel increments to a TC. The population covered, distribution of estimated transport times, and estimated population covered by a specific TC were also calculated for each model.

Results: The single TC model (Fig 1) covered an estimated population of 1,093,186. The predicted median transportation time was 26.2 minutes. In model 1, with a second TC placed to optimize coverage, the population served with both centers increased by 7.7%, while the population served by the existing TC decreased by 8.5%. Median transportation time to the nearest TC was 21.1 minutes. Model 2 (Fig 2), with 3 TC, increased population covered by 10.7%, while that covered by the existing TC decreased by 18.1%. Median transportation time to the nearest TC decreased to 18.5 minutes.

Conclusion: Geo-spatial analysis can provide objective measures of population access to trauma care, including the estimated population within 60 minutes of a TC, the distribution of transport times to a TC, and the population covered by a specific TC. The analysis can be performed using different numbers and locations of TC, allowing direct comparison of changes in coverage and impact on existing centers. This type of data is essential to guide difficult decisions regarding trauma center designation in order to optimize access to care and allocation of resources.

Fig. 1: Single TC Model

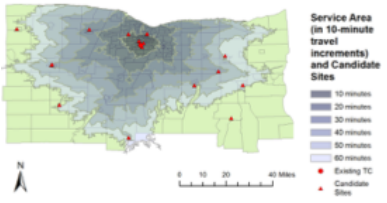
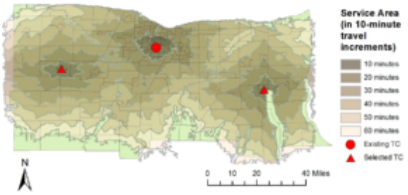


Fig. 2: Three TC Model



Time to nearest TC in minutes

	Average	1st Quartile	Median	3rd Quartile	Pop. w/in 60 min.	Projected volume of existing TC
Existing TC	26.15	8.92	15.67	38.87	1,093,186	1,093,186
Model 1	21.11	8.45	14.77	29.45	1,177,760	1,000,434
Model 2	18.48	8.22	14.57	26.36	1,210,033	895, 617

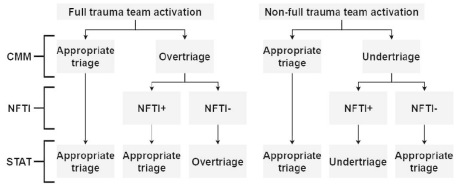
Session: Session IV: Papers 9-16 Trauma Systems
Paper 11: 2:55-3:15 pm

AVOIDING CRIBARI GRIDLOCK 2: THE STANDARDIZED TRIAGE ASSESSMENT TOOL (STAT) OUTPERFORMS THE CRIBARI MATRIX METHOD (CMM). A REPLICATION STUDY IN 35 ADULT AND PEDIATRIC TRAUMA CENTERS.

Jacob W. Roden-Foreman BA, Nakia R. Rapier RN, Michael L. Foreman* MD, Chris Cribari* MD, Megan Parsons BS, Raymond A. Coniglio MSN, Abigail R. Blackmore RN, Cassie A. Lyell RN, Stephanie D. Flohr RN, Marie Campbell RN, The Trauma Measurement Workgroup Baylor University Medical Center At Dallas

Invited Discussant: James Davis, MD

Introduction: CMM is widely used to identify over/undertriage (OT/UT) but requires case review to correct for the inadequacies of ISS. We previously developed the Need For Trauma Intervention (NFTI), which uses registry variables likely to be considered in case reviews to indicate major trauma based on resource consumption. Patients meeting any NFTI criteria are labeled NFTI+ indicating major trauma. Patients meeting no NFTI criteria are NFTI-. STAT was developed as a NFTI-adjusted version of the CMM that emulates the case review process as shown in the flowchart. This multicenter study attempted to replicate a single-center study presented at AAST in 2017 where STAT safely reclassified 52% of CMM OT/UT. We predicted lower injury burdens for OT and higher burdens for UT.



Methods: 35 adult and pediatric US trauma centers submitted data for 88,083 patients. Generalized estimating equations with robust standard errors modeled the effects of OT/UT vs. appropriate triage by triage metric on the odds of mortality and complication, as well as percent difference in total length of stay (LOS) and in number of procedures performed within three days. Total LOS and number of procedures within three days were used as surrogates for overall and early resource consumption, respectively. All models controlled for age, injury mechanism, and site-level effects.

Results: The median CMM OT rate was 53% vs. 32% with STAT. The median CMM UT rate was 22% vs. 3% with STAT. CMM and STAT OTs had significantly reduced odds of mortality and complication, shorter LOSs, and fewer early procedures, but the reductions were significantly larger with STAT. STAT UTs had significantly higher odds of mortality and complication, longer LOS, and more early procedures vs. CMM UTs. CMM UT was not associated with complication risk and was negatively associated with mortality and number of early procedures.

	CMM overtriage	p-value	STAT overtriage	p-value
Mortality, AOR (95% CI)	0.26 (0.19, 0.36)	<0.001	0.01 (0.00, 0.02)	<0.001
Complication, AOR (95% CI)	0.51 (0.41, 0.63)	<0.001	0.23 (0.16, 0.33)	<0.001
Total LOS, % difference (95% CI)	-20.84% (-29.15, -11.55)	<0.001	-44.48% (-51.71, -36.16)	<0.001
Procedures in 3 days, % difference (95% CI)	-19.07% (-25.03, -12.64)	<0.001	-29.64% (-35.54 -23.19)	<0.001

	CMM undertriage	p-value	STAT undertriage	p-value
Mortality, AOR (95% CI)	0.80 (0.67, 0.95)	0.011	23.18 (19.03, 28.22)	<0.001
Complication, AOR (95% CI)	1.01 (0.87, 1.19)	0.868	6.12 (4.57, 8.22)	<0.001
Total LOS, % difference (95% CI)	19.75% (9.59, 30.84)	<0.001	93.47% (70.01, 120.16)	<0.001
Procedures in 3 days, % difference (95% CI)	-8.98% (-14.59, -3.01)	0.004	79.88% (63.01, 98.49)	<0.001

Conclusion: While case review is the ultimate determinant, STAT safely reclassified 76% of CMM OT/UT. Though the degree of improvement varied by center, STAT was substantially more accurate than CMM. This multicenter replication confirms that STAT can flag a smaller portion of patients for more detailed review and reduce the amount of subjectivity introduced by manual triage determinations. This may allow trauma centers to better refine activation criteria and reduce workload.

Session: Session IV: Papers 9-16 Trauma Systems
Paper 12: 3:15-3:35 pm

Effect of Damage Control Laparotomy on Major Abdominal Complications and Lengths of Stay: a Propensity Score Matching and Bayesian Analysis

John A. Harvin* MD, John P. Sharpe MD, Martin A. Croce* MD, Michael D. Goodman MD, Timothy A. Pritts* MD,Ph.D., Elizabeth D. Dauer MD, Benjamin J. Moran MD, Rachel D. Rodriguez MD, Ben L. Zarzaur* MD,MPH, Laura A. Kreiner MD, Jeffrey A. Claridge* MD, John B. Holcomb* MD, University of Texas Medical School-Houston

Invited Discussant: Peter Rhee, MD, MPH

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:
In patients for whom surgical equipoise exists for damage control laparotomy (DCL) and definitive laparotomy (DEF), the effect of DCL and its associated resource utilization are unknown. We hypothesized that DEF would be associated with fewer abdominal complications and less resource utilization.

Methods:
In 2016, 6 US Level 1 trauma centers performed a year-long, prospective, quality improvement project with the primary aim to safely decrease the use of DCL. From this prospective cohort of patients of undergoing emergent trauma laparotomy, a group who underwent DCL but were retrospectively judged by majority faculty vote to have been candidates for definitive laparotomy (potential DEF or pDEF). These pDEF patients were matched in a 1:1 ratio using propensity scoring to the DEF patients. The primary outcome was the incidence of major abdominal complications (MAC), defined as fascial dehiscence, organ/space surgical site infection, reopening of fascia, enteric suture line failure, and secondary outcomes were lengths of stay (hospital-/ICU-/ventilator-free days). Deaths within 5 days were excluded. Outcomes were assessed using Bayesian multilevel generalized linear modeling and negative binomial regression.

Results:
872 total patients were enrolled, 639 (73%) DEF and 209 (24%) DCL. Of the 209 DCLs, 44 were judged to be patients who could have safely been closed at the primary laparotomy and survived 5 days. 39 of these pDEF patients were matched to 39 DEF patients. There were no difference in: demographics; mechanism of injury; Injury Severity Score: prehospital/emergency department/operating room vital signs, labs, and resuscitation; procedures performed during laparotomy. There was no difference in MAC between the two groups (31% DEF vs 21% pDEF, relative risk 0.99, 95% credible interval 0.60 – 1.54, posterior probability 56%). DEF was associated with a 72%, 77%, and 72% probability of more hospital-, ICU-, and ventilator-free days, respectively (Table).

	DEF (n=39)	pDEF (n=39)	Incidence Rate Ratio	95% Credible Interval	Posterior Probability
Hospital-free days	15 (0, 21)	13 (0, 17)	1.30	0.60 – 2.49	72%
ICU-free days	26 (13, 29)	21 (10, 25)	1.17	0.79 – 1.68	77%
Ventilator-free days	29 (20, 30)	26 (14, 28)	1.12	0.79 – 1.53	72%

Conclusion:
In patients for whom surgeons have equipoise for damage control laparotomy versus definitive surgery, definitive abdominal closure was associated with no difference in major abdominal complications, but was associated with more hospital-, ICU-, and ventilator-free days.

Session: Session IV: Papers 9-16 Trauma Systems
Paper 13: 3:35-3:55 pm

TRAUMA SYSTEM RESOURCE PRESERVATION: A SIMPLE SCENE TRIAGE TOOL CAN REDUCE HELICOPTER EMERGENCY MEDICAL SERVICES (HEMS) OVER-UTILIZATION IN A STATE TRAUMA SYSTEM

Pascal Udekwu* MBA,MD, Sharon Schiro Ph.D., Eric Toschlog* MD, Meagan Farrell Ph.D., Sarah McIntyre RN, BSN, James Winslow III, MD, North Carolina Trauma Registry

Invited Discussant: Mark Gestring, MD

Introduction:The intent of HEMS is to improve outcomes in time sensitive injuries. Although some studies have purported that HEMS improves survival, they are hampered by limitations in methodology, and doubts remain regarding HEMS value. Given the cost and risk associated with HEMS, the purpose of our study was to identify scene variables that mitigate inappropriate utilization.

Methods:A state trauma registry was utilized to identify patients admitted 2013-2015. Logistic regression was utilized to evaluate the influence of scene variables on mortality in ground (GEMS) and HEMS cohorts. Variables were analyzed across the GEMS/HEMS cohorts to assess impact on mortality. Time sensitive injuries (TSI) to the trauma center were defined as Emergency Department (ED) death, dispositon to Operating Room, Invasive Procedure or Intensive Care Unit.

Results: The statewide registry accrued 94,558 patients in the period 2013-2015 of whom 71,623 were transported by GEMS and 9,180 by HEMS. 60.7% of GEMS responses were from the scene as were 50.8% of HEMS responses. Percentage of HEMS scene responses increased from 7.28% to 9.29% from 1987-1993 data previously published, total scene flights increased from 192/year to 1,554/year. Age, gender, injury type, systolic blood pressure, pulse rate and Glasgow Coma Scale Score – Motor (GCS-M) were all significantly associated with mortality as continuous variables. To create a triage model differentiating normal from abnormal information; age, systolic blood pressure, respiratory rate, pulse and injury types were converted to categorical variables where age 16.0 - 69.9, blunt injury type, systolic blood pressure greater than 90, pulse 60 – 120, respiratory rate 10 – 30 and GCS-M 6 were considered normal. Logistic regression demonstrated a strong association between these variables and mortality and incorporating all variables allowed for creation of a low risk category. HEMS and GEMS patients were separated into two groups based on these characteristics and compared. Mortality rate (MR) was low and not significantly different in HEMS and GEMS low risk patients (1.5% vs 1.3%). MR was highest in the HEMS patients not selected as low risk (12.6%). 1815 or 38.9% of all HEMS patients fell into our low risk model. 1134 (62.5%) of low risk patients were perceived not to have TSI and 15.1% were discharged home. The dominant HEMS vendor reported an average revenue of $12,875.00 per patient in 2016. Estimated revenue for all low risk patients in this study was $23.4 million, for low risk patients without TSI, $14.6 million and for patients discharged home from the emergency department, $3.5 million. For comparison, ground ambulance costs were calculated at $224 - $2204 per ride for Medicare beneficiaries in 2016, using the high estimate cost for transporting all low risk patients by ground would cost $4.0 million, with a savings of $19.4 million.

Conclusion: Adult patients with normal vital signs and GCS-M 6 can be safely transported by GEMS with no increase in mortality from HEMS. Implementing a simple “no fly” decision tool could significantly reduce inappropriate HEMS utilization and reduce trauma system costs.

Session: Session IV: Papers 9-16 Trauma Systems
Paper 14: 3:55-4:15 pm

LONG-TERM OUTCOMES AFTER SINGLE-LOOK TRAUMA LAPAROTOMY: A LARGE POPULATION-BASED STUDY

Jason Bowie MD, Jayraan Badiee MPH, Richard Y. Calvo Ph.D., Michael J. Sise* MD, Lyndsey E. Wessels MD, William J. Butler MD, Casey E. Dunne MPH, C. Beth Sise MSN, Vishal Bansal* MD, Scripps Mercy Hospital Trauma Service

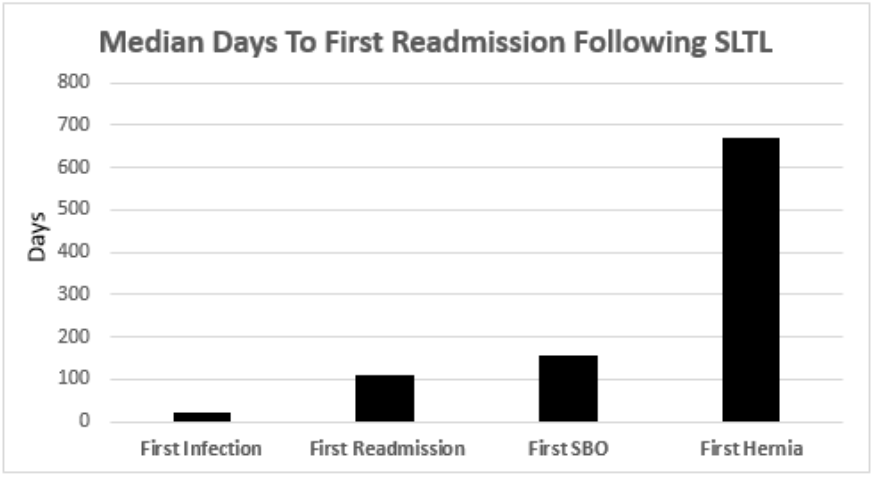
Invited Discussant: Adil Haider, MD, MPH

Introduction: Although damage control laparotomy for trauma has been studied in detail, the outcomes for patients who require only one operation, single-look trauma laparotomy (SLTL) have not been well studied. We evaluated the association between SLTL and long-term outcomes in a large, population-based dataset.

Methods: The California Office of Statewide Planning and Development patient discharge (OSHPD) database was evaluated for calendar years 2007-2014. Patients with SLTL during their index admission were identified using ICD-9-CM procedure codes. Diagnosis and procedure codes were evaluated for specific abdominal organ injuries, surgical interventions, and perioperative complications. Subsequent acute care admissions were evaluated for post-operative complications and additional related surgical interventions. Variations among clinical characteristics, injuries, surgical interventions, and outcomes were evaluated by mechanism of injury.

Results: There were 2,113 trauma patients with SLTL at their index admission; 712 (33.7%) had at least one readmission to an acute care facility with a median time to first readmission of 110 days. Penetrating mechanism was more common than blunt (61% vs. 39%). Blunt-injured patients had a significantly higher ISS compared to those patients with a penetrating injury (median 18 vs. 9, $p < 0.0001$), and significantly higher rate of mortality during their index admission (27% vs. 4%, $p < 0.0001$). Over 30% of SLTL patients requiring readmission had a surgery-related complication, with the most common primary reason for readmission being bowel obstruction (17.7%), followed by infection (9%) and incisional hernia (7%). There was no significant difference between the mechanism of injury and the development of surgery-related complications requiring readmission.

Conclusion: Patients requiring trauma laparotomy continue to have high rates of post-injury morbidity and mortality with over 10% of SLTL patients developing a surgery-related complication requiring readmission. This rate did not vary by mechanism. All SLTL patients who survive to discharge are at significant risk for subsequent complications and should be educated on the signs and symptoms of these common complications. Further investigation should focus on the factors associated with the development of these complications.



Session: Session IV: Papers 9-16 Trauma Systems
Paper 15: 4:15-4:35 pm

PRE-HOSPITAL TOURNIQUET USE IN PENETRATING EXTREMITY TRAUMA: DECREASED BLOOD TRANSFUSIONS AND LIMB COMPLICATIONS

Alison A. Smith MD,Ph.D., Joana Ochoa MD, Sunnie Wong BA, Sydney Beatty BS, Jeff Elder MD, Chrissy Guidry DO, Patrick McGrew MD, Juan Duchesne* MD, Rebecca Schroll MD, Tulane School of Medicine

Invited Discussant: Joseph DuBose, MD

Introduction: Despite increasing popularity of pre-hospital tourniquet use in civilians, few studies have evaluated the efficacy and safety of tourniquet use. Furthermore, previous studies in civilian populations have focused on blunt trauma patients. The objective of this study was to determine if pre-hospital tourniquet use in patients with major penetrating trauma is associated with differences in outcomes compared to a matched control group.

Methods: An eight-year retrospective analysis of adult patients with penetrating major extremity trauma amenable to tourniquet use
(major vascular trauma, traumatic amputation and near-amputation) was performed at a level I trauma center. Patients with pre-hospital tourniquet placement (TQ) were identified and compared to a matched group of patients without tourniquets (N-TQ) and similar limb injury severity. Univariate analysis was used to compare outcomes in the groups.

Results: A total of 204 patients were included with 127 (62.3%) in the TQ group. No differences in patient demographics or injury severity existed between the two groups. Average time from tourniquet application to arrival in the ED was 22.5 $\pm$1.3 minutes. Patients in the TQ group had higher average SBP on arrival in the ED (120.4$\pm$1.7 vs. 112.3 $\pm$2.1, p=0.0033). TQ group required less total PRBCs (2.0$\pm$0.1 vs. 9.3$\pm$0.6, p<0.0001) and FFP (1.4$\pm$0.08 vs. 6.2$\pm$0.4, p<0.0001). Tourniquets were not associated with nerve palsy (p=0.33) or secondary infection (p=0.43). Fasciotomy was significantly higher in the N-TQ group (12.6% vs. 31.4%, p=0.0008) as was limb amputation (0.8% vs. 9.1%, p=0.005).

Table 1. Outcomes for pre-hospital (TQ) vs. no pre-tourniquet (N-TQ) in patients with penetrating extremity trauma

Outcomes	Total n=204	TQ n=127	N-TQ n=77	p
Average injury severity score (SEM)	9.4 (0.6)	9.0 (0.5)	10.1 (0.6)	0.17
Average AIS of injured limb (SEM)	2.8 (0.2)	2.8 (0.2)	2.7 (0.2)	1.0
Average ER SBP, mmHg (SEM)	117.4 (1.9)	120.4 (1.7)	112.3 (2.1)	**0.0033**
Shock (SBP<90 mmHg) on arrival, n (%)	34 (16.7)	17 (13.4)	17 (22.1)	0.12
Mortality, n (%)	19 (9.3)	9 (7.1)	10 (13.0)	0.21
Total PRBCs, avg units (SEM)	4.4 (0.3)	2.0 (0.1)	9.3 (0.6)	**<0.0001**
Total FFP, avg units (SEM)	1.9 (0.1)	1.4 (0.08)	6.2 (0.4)	**<0.0001**
Nerve palsy, n (%)	10 (4.9)	8 (6.3)	2 (2.6)	0.33
Secondary infection, n (%)	7 (3.4)	3 (2.3)	4 (5.2)	0.43
Secondary limb loss, n (%)	8 (3.9)	1 (0.8)	7 (9.1)	**0.005**
Fasciotomy, n (%)	43 (21.1)	16 (7.8)	27 (35.0)	**0.0003**

Conclusion: This study demonstrated that pre-hospital tourniquets could be safely used to control bleeding in major extremity penetrating trauma with no increased risk of major complications. Pre-hospital tourniquet use was also associated with increased SBP on arrival to the ED, decreased blood product utilization and decreased incidence of limb related complications, which may lead to improved
long-term outcomes and increased survival in trauma patients.

Session: Session IV: Papers 9-16 Trauma Systems
Paper 16: 4:35-4:55 pm

What is the Best Surgical Management for Duodenal Trauma? A Panamerican Trauma Society (PTS) Multi-CenterTrial

Paula Ferrada* MD, Juan Duchesne* MD, Gustavo Fraga* MD, Elizabeth Benjamin* MD, Andre Campbell* MD, Aberto Garcia MD, Carlos Morales MD, Bruno Pereira MD, Marcelo Ribeiro MD, Martha Quiodettis* MD, Gregory Peck DO, Juan C. Salamea MD, Vitor Kruger MD, Rao Ivatury* MD, Thomas Scalea* MD, Virginia Commonwealth University

Invited Discussant: Gregory Jurkovich, MD

Introduction: The operative management of duodenal trauma remains controversial. We hypothesized that a simplified operative approach could be safe and effective.
Methods: We conducted an international multicenter study, involving 11 PTS centers, and retrospectively reviewed duodenal injury management from January 2007 to December of 2016. Using the Research Electronic Data Capture (REDCap) tool, data on demographics, mechanism, blood loss, operative time, and associated injuries were collected. Outcomes included post-operative intra-abdominal sepsis, leak, need for unplanned surgery, length of stay, renal failure, and mortality.
Results: We collected data in 372 patients with duodenal injuries. Penetrating trauma was the most common mechanism (blunt 21%, penetrating 79%). 253 patients (68%) had associated injuries, included colon (128), pancreas (107), stomach (90), kidney (44), IVC (34), Liver (24), spleen (23), bile ducts (20), diaphragm (14), and aorta (3). Patients were badly injured with a mean ISS of 22, mean abdominal AIS of 4, and AAST grade 3 duodenal injuries. However, primary repair alone was the most common operative strategy (80%). Overall mortality was 24%. On a univariate analysis, mortality was associated with male gender, lower admission systolic blood pressure, preop transfusion, higher blood loss, longer operative time, renal failure needing dialysis, higher ISS, and associated pancreatic injury. On logistic regression, higher ISS, associated pancreatic injury, renal failure requiring dialysis and need for pre-op transfusion remained significant predictors of mortality. There was no statistical difference regarding ISS, operative time, pre-op transfusion requirement and mortality between various surgical techniques. Sepsis, leaks, and need for unplanned surgeries were statistically lower in patients that had 1 primary repair.(Table 1)
Conclusions: Need for pre-op transfusion, associated pancreatic injuries and renal failure predict mortality after duodenal injury. Primary repair alone is common and safe, even for complex injuries ß (Table abbreviations: PADT=repair with antegrade duodenal tube, or with a duodenostomy tube, with or without jenunostomy, PEwGJ =pyloric exclusion with gastrojejunostomy, PE without GE = Pyloric exclusion without gastrojejunostomy)

Type of Repair	PADT (n=37)	PE w GJ (n=16)	PE wo GJ (n=13)	Other Repair (n=7)	Primary (n=299)	p value
Mortality (Yes)	7 (18.9%)	2 (12.5%)	5 (38.5%)	2 (28.6%)	73 (24.4%)	0.5023
Transfusion before OR	20 (57.1%)	3 (25%)	7 (53.9%)	2 (28.6%)	142 (47.7%)	0.3044
Unplanned Surgeries	17 (46%)	11 (68.8%)	4 (30.8%)	4 (57.1%)	82 (27.2%)	0.0009
Renal Failure	3 (8.1%)	0	2 (15.4%)	0	19 (6.3%)	0.4586
Ventilator > 3 days	13 (35.1%)	10 (62.5%)	5 (38.5%)	5 (71.4%)	55 (18.3%)	<0.0001
Repair Leak	3 (42.9%)	7 (43.8%)	7 (53.9%)	3 (42.9%)	32 (10.6%)	<0.0001
Sepsis	14 (37.8%)	9 (56.3%)	5 (38.5%)	3 (42.9%)	47 (15.6%)	<0.0001
ISS median	25 (16 - 27)	17 (15 - 34)	21 (16 - 26)	18 (16 - 34)	22 (16 - 27)	0.9005
Age	24 (19 - 37)	24.5 (21.5 - 33.5)	22 (21 - 37)	26 (18 - 27)	29 (21 - 40)	0.4722
AAST	3(2 - 3)	3 (3 - 3)	3 (3 - 3)	5 (4 - 5)[1]	3 (3 - 3)	0.0002
Hospital LOS	19 (9 - 28)	19 (10.5 - 55)	10 (3 - 17)	31 (19 - 56)	11 (6 - 22)	0.0137
ICU LOS	4 (2 - 11)	6 (5 - 26)	4 (2 - 14)	27 (7 - 33)	2 (0 - 8)[2]	<0.0001

Session: Session VIII: Papers 17-20
Paper 17: 7:30-7:50 am

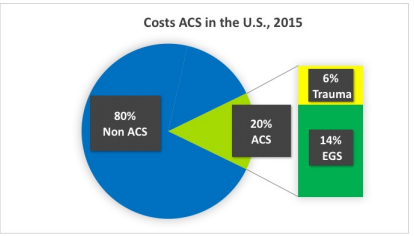
THE ECONOMIC FOOTPRINT OF ACUTE CARE SURGERY IN THE UNITED STATES: IMPLICATIONS FOR SYSTEMS DEVELOPMENT

Lisa M. Knowlton MD,MPH, Joseph Minei* MBA,MD, Andrew Bernard* MD, Kimberly A. Davis* MBA,MD, Jay Doucet* MD, Adil Haider* MD,MPH, Tres Scherer* MBA,MD, Kristan L. Staudenmayer* MD, MS AAST Healthcare Economics Committee

Invited Discussant: David Hoyt, MD

Introduction: Acute Care Surgery (ACS) comprises Trauma, Surgical Critical Care, and Emergency General Surgery (EGS), encompassing both operative and non-operative conditions. Acute care surgeons also serve as primary admitting as well as consulting physicians for ACS conditions. While the burden of EGS and trauma have been separately considered, the global footprint of ACS has not been fully characterized. Furthermore, the makeup of ACS practice has anecdotally been described as varying between institutions. We sought to characterize the scope of influence of ACS-related conditions, even when these are not the primary reasons for admission. We hypothesized that ACS patients comprise a substantial portion of the U.S. inpatient population. We further hypothesized that the ratio of trauma and EGS differs substantially across organizations, reflecting the variability among ACS practices.

Methods: We queried the National Inpatient Sample (NIS), a nationally representative database for inpatient hospitalizations. These most recent data include inpatient admissions from January to September 2015. In order to capture all adult ACS patients, we included adult admissions with any ICD-9-CM diagnosis of trauma or an ICD-9-CM diagnosis for one of the 16 AAST-defined EGS conditions. Weighted patient data are presented to provide national estimates.



Results: Of the 29.7 million adult patients admitted to U.S. hospitals, approximately 4.7 million (14%) patients had an ACS diagnosis over the 9-month study period. ACS patients accounted for $70.3 billion dollars, or 20% of total U.S. inpatient costs ($357 billion). EGS comprised the greatest proportion of the ACS population (3.4 million, or 72%). When comparing ACS to non-ACS inpatient populations, ACS patients had higher rates of healthcare utilization with longer lengths of stay (6.0 vs. 4.5 days, $p<0.001$), and higher mean costs ($15,057 vs. $11,464, $p<0.001$. Of all inpatients undergoing an operative procedure, 27% were patients with an ACS diagnosis. We next determined the mix of ACS patients at hospitals. Overall, 3,153 (70%) of U.S. hospitals cared for both trauma and EGS patients. The median percent of ACS to all patients in these centers was 16% (IQR: 13%-18%). The percent of all ACS patients who were trauma patients was similarly variable, with a median of 28% (IQR: 21%-33%).

Conclusion: Acute care surgery patients comprise 14% of the inpatient population, but 20% of total inpatient costs in the U.S. Furthermore, almost 1/3 of all inpatient operations were for an ACS diagnosis. These findings suggest that ACS conditions have the ability to significantly impact local and national healthcare and costs. Furthermore, as EGS comprises 70%-80% of ACS activities, the greatest impact may lie in improvements in care for the EGS population.

Session: Session VIII: Papers 17-20
Paper 18: 7:50-8:10 am

HOW MUCH GREEN DOES IT TAKE TO BE ORANGE? DETERMINING COST ASSOCIATED WITH TRAUMA CENTER READINESS

Dennis W. Ashley* MD, Robert F. Mullins MD, Christopher J. Dente* MD, Laura E. Garlow MHA, BSN, TCRN, RN, Regina S. Medeiros DNP, RN, Elizabeth V. Atkins MSN, RN, Gina Solomon RN, CCRN, TCRN, Dena Abston Colville H. Ferdinand MD, Medical Center of Central Georgia/Mercer University School of Medicine

Invited Discussant: John Fildes, MD

Introduction: Readiness Costs are real expenses incurred by trauma centers to maintain essential infrastructure to provide emergent services on a 24/7 basis. Although the components for readiness are well described in the American College of Surgeon's *Resources for Optimal Care of the Injured Patient* (Orange Book), the cost associated with each component or regulation is not well defined nor accounted for by standard hospital accounting systems. The purpose of this study was to quantify the cost of trauma center readiness based on these criteria.

Methods: The state trauma commission in conjunction with trauma medical directors, program managers, and financial officers of each trauma center standardized definitions for each component of trauma center readiness cost and developed a survey tool for reporting them. Components of readiness were grouped into four main categories: Administrative Support, Clinical Medical Staff Support, In-House Operating Room Services, and Education/Outreach with appropriate subcategories. To verify consistent cost reporting, an independent financial auditor reviewed all data. Trauma centers noted to be outliers were further reviewed to validate significant variances. The survey was completed by all designated Level I and Level II trauma centers (n=16) statewide based on calendar year 2016 data.

Results: Average annual readiness cost is $10,078,506 for a Level I trauma center and $4,925,103 for a Level II center. The clinical medical staff was the costliest component representing 55% of costs for Level I trauma centers and 65% for Level II's. Although education/outreach is mandated, Level I and II trauma centers only spend on average approximately $100,000 annually on this category (1-2%) demonstrating a relative lack of resources in this area.

Cost Category	LI Total (N=6)	LI Average	LII Total (N=10)	LII Average	Totals (N=16)
Administrative	$21,596,097	$3,599,350	$13,922,472	$1,392,247	$35,518,570
Clinical Medical Staff	$33,203,255	$5,533,876	$31,716,530	$3,171,653	$64,919,786
In House OR	$4,980,890	$830,148	$2,521,596	$252,160	$7,502,486
Education/Outreach	$690,793	$115,132	$1,090,426	$109,043	$1,781,219
Totals	$60,471,035	$10,078,506	$49,251,024	$4,925,103	$109,722,061

Conclusion: This study defines the cost associated with each component or regulation of readiness as defined in the American College of Surgeons *Resources for Optimal Care of the Injured Patient* manual. Average readiness cost for a Level I trauma center is $10,078,506 and $4,925,103 for a Level II. The significant cost of trauma center readiness highlights the need for additional trauma center funding to meet the requirements set forth by the American College of Surgeons.

Session: Session VIII: Papers 17-20
Paper 19: 8:10-8:30 am

MEDICAID EXPANSION ASSOCIATED WITH INCREASED ACCESS TO POST-DISCHARGE CARE FOR TRAUMA PATIENTS

John W. Scott MD,MPH, Pooja U. Neiman MD, MPA, Tarsicio Uribe-Leitz MD,MPH, Cheryl K. Zogg MSPH, MHS, Ali Salim* MD, Adil H. Haider* MD,MPH, Center For Surgery And Public Health, Department Of Surgery, Brigham And Womens Hospital

Invited Discussant: Andrew Bernard, MD

Introduction: UUninsured trauma patients have worse outcomes and worse access to critically important post-discharge care. As a part of the Affordable Care Act (ACA), 33 states expanded Medicaid eligibility criteria in 2014, in an effort to increase access to insurance coverage. The national impact of Medicaid expansion on trauma patients is not well understood.

Methods: We used the 2011-2016 National Trauma Data Bank (NTDB) to evaluate for changes in insurance coverage among 18-64 year-old trauma patients admitted to level 1 and level 2 trauma centers. Our pre-/post- Medicaid expansion models used 2011-2013 as the pre-policy period, 2015-2016 as the post-policy period, and 2014 as a washout year. To evaluate for policy-associated changes in inpatient mortality and discharge disposition, we used a risk-adjusted before-and-after linear model, which accounted for year-to-year variation in patient demographics, injury characteristics, and facility traits.

Results: We identified 1,961,102 patients meeting inclusion criteria over the six-year study period. Prior to 2014 there were no significant year-to-year changes in rates of private insurance, Medicaid, and no insurance coverage ($p>0.05$). The table shows pre- and post-policy insurance coverage rates. Notably, rates of private insurance were unchanged. The uninsured rate, however, fell by over a quarter. This change was driven by the >50% relative increase in Medicaid coverage post-expansion. No changes in inpatient mortality were observed ($p=0.314$). However, a significant increase in the rate of discharge to a facility, an increase in discharge with home services, and a decrease in the rate of discharge to home was noted ($p<0.001$ for all).

Conclusion: Although only two-thirds of states have elected to expand Medicaid eligibility through the ACA, this policy has led to a large reduction in the uninsured rate among US trauma patients. The observed increases in insurance coverage were not associated with changes in mortality, but were associated with greater access to post-discharge care—critically important to patient recovery and wellbeing after trauma.

TABLE

	Unadjusted Analyses				Risk Adjusted Analyses[b]		
	Pre-Policy[a]	Post-Policy[a]	Unadj. Difference	p-value	Adj. Difference	Relative Change	p-value
Insurance Coverage							
Private	46.9%	46.9%	0.0%	0.75	-0.6%	-1.2%	0.30
Medicaid	13.4%	20.9%	**7.5%**	<0.001	**7.6%**	56.7%	<0.001
Uninsured	23.5%	17.5%	**-6.0%**	<0.001	**-6.1%**	-26.1%	<0.001
Clinical Endpoints							
Inpatient Mortality	2.6%	2.6%	0.0%	0.549	0.1%	2.7%	0.314
Discharge to Facility[c]	14.7%	17.3%	**2.6%**	<0.001	**3.7%**	24.9%	<0.001
Discharge to Home[c]	83.8%	80.9%	**-2.9%**	<0.001	**-4.2%**	-5.0%	<0.001
Home Services[d]	6.7%	8.6%	**1.9%**	<0.001	**2.6%**	38.8%	<0.001

Source: Authors interpretation of data from the National Trauma Data Bank, 2011-2016. Unadj, unadjusted. Adj, adjusted. Diff, difference. **a**: Pre-policy period is 2011-2013, Post-policy period is 2015-2016. **b**: Insurance coverage analyses adjusted for facility-level fixed effects. Clinical endpoints adjusted for year, age, sex, injury severity score, revised trauma score, injury mechanism, injury intent, intensive care unity stay, trauma center designation level, hospital bedsize, teaching status, US census region, and facility. **c**: Among patients surviving to discharge. **d**: Among patients discharged home.

Session: Session VIII: Papers 17-20
Paper 20: 8:30-8:50 am

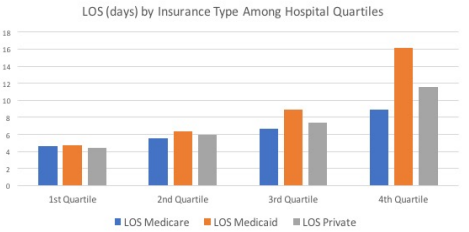
ASSOCIATION BETWEEN LENGTH OF STAY AND ACCESS TO POST-ACUTE CARE: CHALLENGES WITH DISPOSITION AND THE IMPACT ON INPATIENT COSTS

Lisa M. Knowlton MD,MPH, Mary T. Hawn MD,MPH, Lakshika Tennakoon MD, Charlotte Rajasingh David A. Spain* MD, Kristan L. Staudenmayer* MD, MS Stanford University Medical Center

Invited Discussant: Jay Doucet, MD, MSc

Introduction: Hospital costs are partly a function of length of stay (LOS), which can be impacted by the local availability of post-acute care resources, particularly for injured patients who require rehabilitation. We hypothesized that LOS for trauma patients destined for rehabilitation would be highly variable based on insurance type and hospitals from which they are discharged.

Methods: We used the 2014-2015 National Inpatient Sample, a nationally representative database for inpatient hospitalizations. We included all admissions with a primary diagnosis of trauma (ICD-9CM codes), ages of 18 to 64, insured, and whose discharge disposition was rehabilitation. We then excluded hospitals that did not treat trauma patients with all three insurance types or those who did not discharge patients to rehabilitation to ensure accurate between-group comparisons. The primary outcome was inpatient LOS; secondary outcome was cost of admission. Centers were divided into quartiles by mean LOS. Univariate and multivariate analyses were performed. Weighted patient data provide national estimates.



Results: Of the 727,900 trauma patients meeting inclusion criteria, 156,305 (22%) treated in 152 hospitals were discharged to rehabilitation and included in the analysis. Mean LOS for trauma patients discharged to rehabilitation was 5.3 days (SD 0.1), with significant variability based upon insurance type (Medicaid vs. Private vs. Medicare: 13.3 vs. 10.4 vs. 7.4 days, $p<0.001$). The mean LOS between quartiles was found to be 4.6 vs. 5.9 vs. 7.4 vs. 12.0 days ($p<0.001$). When comparing LOS by insurance type within each hospital group, there were significant differences. The top 25% of hospitals had a marginal variation in LOS based on insurance types (Medicaid vs. Private vs. Medicare: 4.7 vs. 4.4 vs. 4.6 days, $p<0.001$). In contrast, the bottom quartile had mean LOS that varied by as much as one week (16.1 vs. 11.6 vs. 8.9 days, $p<0.001$). Multivariate regression controlling for patient characteristics and injury factors revealed that Medicaid patients overall spent an additional 2.8 inpatient days compared to other insurance types (95% CI: 2.21-3.31, $p<0.001$). However, there was no difference in Medicaid patient LOS in the top 25%, when controlling for known confounders. The average daily cost of inpatient care was $3,500 (SD $132). Applying this average, Medicaid patients at hospitals without easy access to rehabilitation experience additional inpatient costs of $16,800.

Conclusion: Prolonged LOS is likely a function of access to post-acute facilities, which is largely out of the hands of trauma centers. These findings highlight that efficiencies in care are magnified by availability of post-acute beds, suggesting that increased availability of post-acute care might help to reduce length of stay.

Session: Session XVA: Papers 21-29: Parellel Session
Paper 21: 1:30-1:50 pm

PEDIATRIC FIREARM INCIDENTS: IT'S TIME TO DECREASE ON-SCENE MORTALITY

Jessica Friedman MD, Kareem Ibraheem MD, Marcus Hoof BS, Alison Smith MD,Ph.D., Riley Santiago BS, Rebecca Schroll MD, Chrissy Guidry DO, Juan Duchesne* MD, Patrick McGrew MD, Tulane University

Invited Discussant: Todd Maxson, MD

Introduction: Previous epidemiological studies on pediatric firearm mortality have focused on overall mortality rather than on-scene mortality. In spite of advances in trauma care the number of potentially preventable deaths remains high. This study utilized the National Emergency Medical Services Information Systems (NEMSIS) database to characterize patterns of on-scene mortality in order to identify patients who may benefit from changes to pre-hospital care practices.

Methods: The NEMSIS database was searched for all pediatric firearm incidents from 1/1/10 - 12/31/15. Information regarding age; gender; intention of incident; wound location, categorized as compressible for extremities and non-compressible for chest, abdomen and back; location of incident, and on-scene mortality was collected and an analysis of variance done. A linear regression model was used to calculate independent predictors of mortality.

Results: A total of 16808 patients were identified, with an on-scene mortality of 6.1%. A large percentage of mortalities suffered cardiac arrest on-scene; 72.6% of these were prior to EMS arrival, which carried a significantly higher mortality rate than cardiac arrest after EMS arrival. No difference was seen in anatomic location of injury in those who arrested before and after EMS arrival. Compressible injuries were most common at and carried the lowest mortality. Non-compressible injuries together accounted for 25.8% of injuries and 23.5% of mortalities. The mortality of self-inflicted gunshot wounds was higher than assault or accidental injury.

Conclusion: To our knowledge, this is the largest study of on-scene mortality in pediatric firearm injury to date. Cardiac arrest prior to EMS arrival was a considerable source of on-scene mortality; significantly more of these patients died than those who arrested after EMS arrival. The mortality of compressible injuries is very low, implying that use of compression and tourniquets have been effective in stopping life-threatening extremity bleeding. Based on our analysis, non-compressible injury mortality could be decreased with education of bystanders and more aggressive on-scene intervention. Consideration of modification of the current Traumatic Cardiac Arrest Treatment Algorithm with more aggressive on-scene interventions could be of benefit. Through the evaluation of on-scene mortality specifically, this study offers insight into potential areas of focus to improve pre-hospital care of pediatric gunshot victims.

Variable	Incidence (% of Total)	Deaths (% of Total)	Mortality	p value
Total	16808	1031	6.1%	<0.001
Cardiac Arrest	914 (5.5)	367 (36.4)	40.1%	<0.001
Prior to EMS	664 (72.6)	326 (88.8)	46.7%*	
After EMS	250 (27.4)	41 (12.2)	9.1%*	
Type of Firearm injuries	16808	1092		<0.001
Accidental	3617 (21.5)	101 (9.2)	2.6%*	
Assault	11215 (66.7)	447 (40.9)	3.7%*	
Self-inflicted	1976 (11.8)	544 (49.8)	36.4%*	
Anatomical Location	9698	570		<0.001
Head	2585 (26.7)	416 (73.0)	15.1%*	
Neck	276 (2.8)	13 (2.3)	4.7%*	
Chest	1025 (10.6)	112 (19.6)	8.8%*	
Abdomen	782 (8.1)	12 (2.1)	1.0%*	
Back	684 (7.1)	10 (1.8)	1.2%	
Extremity	4271 (44.0)	7 (1.2)	0.1%*	

Session: Session XVA: Papers 21-29: Parellel Session
Paper 22: 1:50-2:10 pm

EFFECT OF MASS SHOOTINGS ON GUN SALES – A 20 YEAR PERSPECTIVE

Rachael A. Callcut* MD, MSPH, Anamaria J. Robles MD, Lucy Z. Kornblith MD, Rebecca E. Plevin MD, Matthew W. Mell MD, M.S. University of California, San Francisco

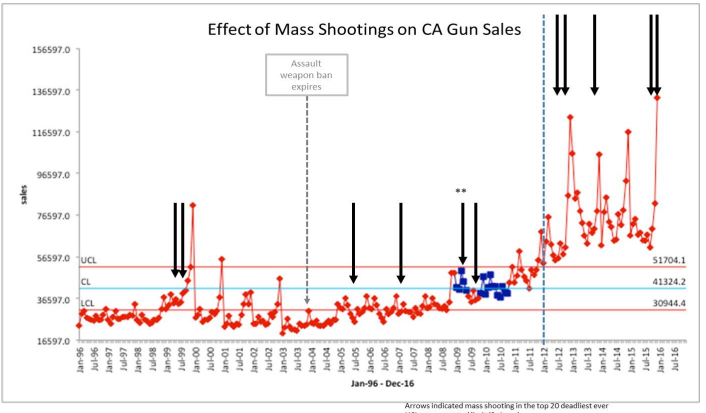
Invited Discussant: Ronald Stewart, MD

Introduction:Granular data on gun sales has been historically difficult to obtain. In 2016, California (CA) made monthly data from 1996-2015 publically available. Control charts are a well-accepted method to analyze how a process changes over time in response to non-routine events. We utilized this technique to study the impact of US mass shootings on CA gun sales.

Methods:Monthly gun sales were provided by the CA Department of Justice and monthly fatalities from the CDC Wonder Death Certificate Registry. Mass shooting events were obtained from after-action reports, news media, and court proceedings. Time ordered data were analyzed with control charts (with upper/lower control limits [UCL, LCL]) using QiMacros.

Results:9,917,811 individual gun sales occurred in CA with a median monthly rate of 41,324 (range 20,057 – 132,903). A median 263 people lost their lives monthly from firearms (124 homicide, 128 suicide), totaling 53,975 fatalities from 1999-2015. 12/20 current deadliest mass shootings occurred during this study period with 42% from 2012-15. Also, 36 school shootings occurred during the study (mean 5 deaths, range 0-33; 6 injuries, range 0-23) with 33% in 2012-15 at rate of 4 events/year vs. 1.4 events/year in the 17 prior years ($p<0.05$). Sales were generally consistent from 1996-2011 (except post Columbine [Col]). Starting in 2012 (Figure), sales exceeded the predicted UCL every single month. Before 2012, there was no statistically significant effect of mass shootings on sales (except briefly following Col); however, since Sandy Hook (SH; 2012), a statistically significant proportional spike in sales occurred in the months immediately following every single deadliest mass-shooting event. Every year since SH, CA has strengthened gun laws in response to mass shootings yet sales have risen immediately preceding enforcement of these laws each January.

Conclusion:Gun sales are more frequent since 2012, with additional spikes following both mass shootings and legislative changes enacted in response to these shootings.



Session: Session XVA: Papers 21-29: Parellel Session
Paper 23: 2:10-2:30 pm

INCREASINGLY PERMISSIVE FIREARM CARRY LEGISLATION IS ASSOCIATED WITH INCREASED FIREARM-RELATED SUICIDE RATES

Matthew C. Hernandez MD, Mark E. Hamill* MD, Kent Bailey Ph.D., Martin D. Zielinski* MD, Henry J. Schiller* MD, Mayo Clinic - Rochester

Invited Discussant: Zara Cooper, MD, MSc

Introduction: Public opinion about where legal gun owners may carry firearms is rapidly changing. State legislation for firearm concealed carry applications and permits (no issue, may issue, shall issue and unrestricted) have been associated with mixed results and inconclusive findings. We aimed to determine whether incremental liberalization of the concealed carry state legislation was associated with firearm related suicides.

Methods: The US Department of Justice Uniform Crime Reporting program (UCR) and Centers for Disease Control (CDC) and Prevention Web-based Injury Statistics Qurery and Reporting System databases were combined into a dataset for 51 states (including D. C.) between 1986 and 2015. Data was collected on rates of all suicide, firearm-related suicide, unemployment, and poverty by state and year throughout this time period. State level data on concealed carry legislation was recorded for every study year, broken down into four broad categories – no carry, may issue, shall issue and no restrictions. Data were analyzed using general multiple linear regression models with Y being the log of the event rate, and main effects for each unique state and year. Legislative status was analyzed both as a scale (no issue, may issue, shall issue and unrestricted), and as a binary variable non-restrictive (shall issue or no restrictions) versus restrictive (may issue or no carry). To allow for non-independence among the serial observations within a state, an autocorrelation structure was implemented in PROC GENMOD using generalized estimating equations (GEE) estimates for standard errors. The standard errors thus obtained were approximately twice as large as those assuming independence.

Results: During the study period, there was liberalization of concealed-carry legislation and is demonstrated by the distributions in Table 1 which also summarizes the temporal changes in the means of the two suicide rates. The mean (±SD) all suicide rate was 13.9 (±3.6) per 100,000 and firearm-related suicide rate was 7.6 (±3.1) per 100,000. The study period poverty rates in 1986 and 2015 were 13.9% (±4.4%) and 13.1% (±5.1%) respectively. The unemployment rates were 6.9% (±2.2%) and 5.1% (±1.1%) during 1986 and 2015. Table 2 shows regression results for both suicide event rates. The variables state and year accounted for 90% of the variation in log (rates). After adjusting for state, year, poverty, and unemployment rate, there was a marginally significant and a significant association of "non-restrictive" legislation on the rates of total and firearm-related suicides resulting in 3.23% +/- 1.70% (p=0.057) and 4.67% +/- 2.21% (p=0.035) increase, respectively. The effect of permission level (no issue, may issue, shall issue and unrestricted) on these two rates also demonstrated marginally significant increasing trends per level increase, 2.54% +/- 1.33% (p=0.057) and 3.21% +/- 1.64% (p=0.050), respectively.

Conclusions: At the macro-level, we demonstrate a relationship between expanding concealed carry firearm applications/permits with suicides committed using a firearm. The study findings were indicative of an increasing relationship with the degree of state firearm concealed-carry legislation liberalization (no carry, may issue, shall issue, and unrestricted). In order to mitigate potential loss of life, suicide prevention efforts might benefit from identifying potential gun owners with known at-risk features.

Table 1

Legislative status and suicide rates in 51 states by year						
Year	**No Carry**	**May Issue**	**Shall Issue**	**No Restrictions**	**All suicide**	**Firearm Suicide**
1986	16	26	8	1	13.7	8.4
1990	14	21	15	1	13.2	8.3
1995	9	14	27	1	12.8	7.9
2000	8	12	30	1	11.6	6.9
2005	3	9	37	2	12.4	6.8
2010	3	9	36	3	14.1	7.5
2015	0	9	35	7	15.8	8.2
Suicide rates are per 100,000 population						

Table 2

Regression Analyses of Gun Legislative Status and Rates of Suicide and Firearm -related suicide				
X-Variable	**Log(Suicide rate)**		**Log(firearm-related suicide rate)**	
Poverty Rate (%)	-0.0007 (0.0015)	-0.0008 (0.0015)	-0.0019 (0.0018)	-0.0022 (0.0018)
Unemployment Rate (%)	-0.0068 (0.0048)	-0.0061 (0.0047)	-0.0163 (0.0059)†	-0.0155 (0.0059)†
Restrictive versus Unrestricted legislation	0.0323 (0.0170)		0.0467 (0.0021)*	
Permission level status (no, may, shall, unrestricted)		0.0254 (0.0133)		0.0321 (0.0164)*

Session: Session XVA: Papers 21-29: Parellel Session
Paper 24: 2:30-2:50 pm

COMPARISON OF MALE AND FEMALE VICTIMS OF INTIMATE PARTNER HOMICIDE IN OPPOSITE SEX RELATIONSHIPS - AN ANALYSIS OF THE NATIONAL VIOLENT DEATH REPORTING SYSTEM

Catherine G. Velopulos MD, MHS, Heather Carmichael MD, Tanya L. Zakrison* MD,MPH, Marie Crandall* MD,MPH, University Of Colorado

Invited Discussant: D'Andrea Joseph, MD

Introduction: Intimate partner violence (IPV) is a growing public health issue, affecting at least 1 in 4 women and 1 in 9 men. Because of their greater numbers, most of the literature focuses on female victims; however, men are at significant risk. A recent multi-center trial on universal screening for IPV in trauma patients showed similar rates of positive screen between men and women. Few studies have explored the bidirectional violence in opposite sex relationships, with this dynamic likely underappreciated. Our goal was to estimate prevalence of and risk factors for the most severe manifestation of IPV, intimate partner homicide (IPH).

Methods: This is a retrospective review of the National Violent Death Reporting System (NVDRS) from 2003-2015, a CDC database comprised of surveillance data from 40 states, the District of Columbia, and Puerto Rico. Deaths were coded as IPV if the primary relationship between the suspect and victim fell into the following categories: spouse, ex-spouse, girlfriend/boyfriend, and ex-girlfriend/ex-boyfriend, collapsed here into "current partner" or "ex-partner." Cases were selected where the victim and suspect were of the opposite sex.

Results: While women were far more likely than men to be the victims in these pairings (79.3%), men constituted a significant proportion at 20.7%. Although current partners were more likely to perpetrate in either situation, male victims were significantly less likely to be murdered by an ex-partner. Black men were the only group to constitute a larger proportion of male victims, with 45.4% of male victims compared to 28.4% of female victims ($p<0.001$). Women were more likely than men to use a stabbing instrument, although firearms were still the most common means for each group. Alcohol was present in a higher proportion of male victims, and a preceding argument was more common. Male victims were also more likely to have been killed in self-defense as determined by detective reports, to have been a perpetrator of violence in the past month, and to survive long enough to be taken to a hospital. Male perpetrators frequently had a history of abusing the victim prior to the homicide (22.1%), and they attempted suicide at the time of the homicide in nearly half of the cases (46.5%), being successful in over one third (35%). There was no difference in mental illness diagnosis between men and women, with a low reported rate at around 7%.

	Female Victim	Male Victim	P value
n = 6131 (%) Opposite Sex Pairings	4861 (79.3)	1270 (20.7)	
Suspect relationship to victim (%)			<0.001
Current partner	3920 (80.6)	1116 (87.9)	
Ex-partner	*729 (15.0)*	*101 (8.0)*	
Unspecified current vs. ex	212 (4.4)	53 (4.2)	
Race/Ethnicity (%)			<0.001
Non-Hispanic White	2685 (55.2)	548 (43.1)	
Black	*1380 (28.4)*	*576 (45.4)*	
Hispanic	464 (9.5)	73 (5.7)	
Other	332 (6.8)	73 (5.7)	
Weapon/Means (%) – Top 3			<0.001
Firearm	2845 (58.5)	607 (47.8)	
Sharp	*896 (18.4)*	*538 (42.4)*	
Strangled/drowned	478 (9.8)	15 (1.2)	
Alcohol Result (%) – If Known			<0.001
Present	*1008 (20.7)*	*525 (41.3)*	
Not present	2533 (52.1)	428 (33.7)	
Preceding Argument (%)	*1502 (30.9)*	*539 (42.4)*	<0.001
Suspect w/Evidence of Justifiable Self Defense (%)	*4 (0.1)*	*81 (6.4)*	<0.001
Suspect Attempted Suicide (%)	*1601 (46.5)*	*84 (11.5)*	<0.001
Jealousy was a motive (%)	510 (10.5)	81 (6.4)	<0.001
Suspect had history of mental illness (%)	*138 (7.5)*	*39 (7.8)*	0.908
Victim was Perpetrator of Violence in Preceding Month (%)	37 (0.8)	63 (5.0)	<0.001
Victim Used Weapon Also (%)	61 (1.3)	79 (6.2)	<0.001
Victim of Violence in Preceding Month (%)	331 (6.8)	30 (2.4)	<0.001
Victim w/Evidence of History of Abuse from Suspect (%)	*843 (22.1)*	*104 (10.4)*	<0.001
Victim was treated in the ED (%)	*476 (9.8)*	*273 (21.5)*	<0.001

Conclusion: Although affected at different rates, homicide due to IPV is a significant public health crisis for both men and women, with women and Black men at particular risk. Firearms are the most commonly used weapon for homicide in both genders, and mental illness is not a common risk factor. A staggering proportion of these homicides involve suicide of the perpetrator, suggesting that each potential incident has two victims to target for prevention and intervention. Interventional programs to prevent such bidirectional mortality are urgently needed.

Session: Session XVA: Papers 21-29: Parellel Session
Paper 25: 2:50-3:10 pm

ESSENTIAL VIOLENCE INTERVENTION RESOURCES: AN UPDATE USING THE NATIONAL NETWORK OF HOSPITAL-BASED VIOLENCE INTERVENTION PROGRAM'S MULTI-INSTITUTIONAL DATABASE

Catherine J. Juillard* MD,MPH, Adaobi Nwabuo MPH, Kim Gajewski BS, Theodore Corbin MD, Jessika Brock BS, Rachel Myers BS, Joel Fein MD,MPH, Anne Marks MPH, Marlene Melzer-Lange MD, Thea James MD, Ariana Perry Ph.D., Rochelle A. Dicker* MD, University of California, Los Angeles

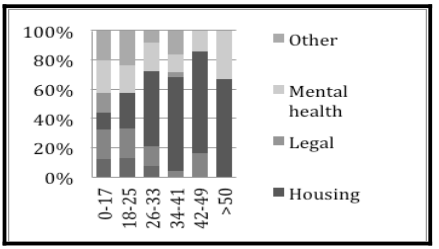
Invited Discussant: Amy Goldberg, MD

Introduction: Violence is a public health issue. Hospital-based violence intervention programs (HVIPs) have been shown to reduce violent re-injury in single institutional studies through mentorship and mitigating risks associated with violent injury. The ACS Committee on Trauma has interest in research into best practices to build HVIPs. The purpose of this study is to identify the most commonly accessed risk reduction resources in HVIPs by examining our multi-center database. We examine success rates in addressing needs.

Methods: The National Network of Hospital-Based Violence Intervention Programs database contains demographic, injury and resource utilization information about clients enrolled in five HVIPs from 2014 to 2017. Resource utilization patterns for HVIP services (education, employment, housing, legal services, mental health, and "other")were determined based on groups of interest (client age, gender, race and ethnicity). Analysis was done using frequency tables to determine proportions of services identified across the various groups of interest. Chi-squared and Fisher's exact tests were used to probe for dependence among the groups of interest.

Results: Of the 1647 clients enrolled, the majority were male (80%) and African American (AA)(86%); the median age of enrolled clients was 23 years. Overall, the most common needs identified were mental health (21%) and housing (20%). AA had a higher rate of identifying mental health and employment as a need compared to other ethnicities(p=0.00). White clients identified housing more frequently(p=0.00). Success in meeting employment needs was greatest in the AA population(p=0.00) whereas meeting the housing need was most successful in the white population(p=0.00). Needs were frequently identified and met in the Latino population but not at a significantly higher rate than other groups. Need by age catagory is listed below.

Conclusion: Early HVIP outcomes include successful enrollment of the target population and capacity to identify and address risk factors associated with violent injury. Our first-ever multi-center HVIP database identifies client needs (risk reduction targets) and ability to address needs. Our results represent a national lens on detailed differences amongst our programs' client risk factors and current abilty to address them. This insight is a critical step in identifying risk reduction activity that could ultimately reduce re-injury. As we add clients and programs to this database, future work will focus on the long term outcome of recidivism. These results can help flegling HVIPs prioritize services offered to demographic groups reflected in their often resource contrained communities.



Session: Session XVA: Papers 21-29: Parellel Session
Paper 26: 3:10-3:30 pm

THE GATE PROGRAM: A MULTIDISCIPLINARY INTERVENTION TO REDUCE JUVENILE GUN VIOLENCE RECIDIVISM AND POTENTIAL MODEL FOR NATIONWIDE EXPANSION

Hahn Soe-Lin MD, MS, Joyce Kaufman MD, Anjali Sarver, Enrique Ginzburg* MD,
University Of Miami Miller School Of Medicine

Invited Discussant: Rochelle Dicker, MD

Introduction:

Youth firearm violence has been a growing and increasingly recognized problem in the United States. Several programs across the country aimed at reducing recurrent gun violence in this vulnerable population have published recidivism rates of 40-50%. For the past 18 years, the GATE Program in Miami-Dade County has provided a unique multidisciplinary intervention encompassing 100 hours of violence education, behavioral modification, and social mentoring. The present study defines its outcomes as a national model for youth firearm recidivism prevention.

Methods:

Retrospective analysis of the Florida Juvenile Justice Department records from 2008-2016 defined a group of youths convicted of firearm related crimes and subsequently enrolled in the GATE program. Cohorts were grouped by youth who demonstrated successful completion of the GATE program versus those who only partially completed the program. At 6 and 12 months after release, records were cross referenced with the Florida Department of Justice criminal record system to prospectively capture rates of new all-comer and firearm specific criminal charges.

Results:

215 youth were included in the prospectively followed cohort at 6 months and 163 youth followed at 12 months after release. The 6-month recidivism rate for any criminal charge was 20.1% for program completers versus 32.9% for those who did not complete the program ($p=0.047$). When excluding unarmed criminal offenses, the recidivism rate dropped to 10.1% versus 22.4% respectively ($p=0.008$). At 12 months, all-comers recidivism was 33.6% for the GATE program completion cohort vs 50% for the incomplete cohort ($p=0.045$). When excluding unarmed offences, the recidivism rates were 18.6% vs 33.9% respectively ($p=0.035$).

Conclusion:

The GATE program has one of the lowest recidivism rates in the country both for firearm and non-firearm related criminal offenses. Its demonstrated efficacy should serve as the basis for expansion to other local and state jurisdictions with the aim of decreasing juvenile gun violence across the country.

Session: Session XVA: Papers 21-29: Parellel Session
Paper 27: 3:30-3:50 pm

USE OF SHOTSPOTTER™ DETECTION TECHNOLOGY DECREASES TRANSPORT TIME FOR PATIENTS SUSTAINING GUNSHOT WOUNDS

Deviney Rattigan MD, Joshua P. Hazelton* DO, Michael Dalton MD, John Gaughan Ph.D., John S. Thompson Kyle Remick* MD, John Porter* MD, Anna Goldenberg DO, Cooper University Hospital

Invited Discussant: Alexander Eastman, MD

Introduction: Shorter transport times in patients sustaining penetrating trauma have been shown to be independently associated with improved survival. Literature has also demonstrated that these patients, when transported by police vehicle vs. EMS, have decreased transport times to a trauma center. The purpose of this study was to delineate if a gunshot detection technology called ShotSpotter ™, which triangulates the location of gunshots and alerts nearby police officers to respond, expedited patient transport to definitive care by increasing the likelihood of police response and patient transport.

Methods: All fatal shooting incidents, with the victim being at least 18 years old, which occurred within the city of Camden, New Jersey from 2006-2016 were retrospectively reviewed. Demographic, geographic, transportation, and field intervention data were collected from medical and police records. We compared fatal shootings where the ShotSpotter ™ technology was activated versus fatal shootings where ShotSpotter™ was not activated. Incidents which involved children, occurred outside the city limits, or where complete data was not available were excluded from the study.

Results: There were 105 fatal shooting incidents which met all of the inclusion criteria, with 24 (23%) resulting in the activation of the ShotSpotter™ system. Victims involved in shootings where the ShotSpotter™ system was activated were more likely to arrive at the trauma center for evaluation and potential resuscitation, rather than being pronounced dead in the field (55% vs 37%;p=0.037). Furthermore, these victims were more likely to be transported by police rather than by EMS (29% vs 6%;p=0.005) and less likely to have field interventions performed (25% vs 60 %;p=0.003). There was no difference in the trauma bay resuscitation efforts or number of procedures performed (intubation, ED thoracotomy, central venous access, chest tube, resuscitative medications) between the two groups (all $p>0.05$). When corrected for distance from the location of incident to the trauma center, we found that transport time in ShotSpotter™ activation incidents was significantly shorter (12min vs 16min;p=0.021).

Conclusion: The use of ShotSpotter™ technology significantly decreased transport time of victims sustaining gunshot wounds, likely due to the increased police transport of these patients rather than waiting for EMS. This resulted in fewer pre-hospital procedures and fewer victims being pronounced dead at the scene. While our data only includes incidents which were fatal, future work will involve studying the use of ShotSpotter ™ technology and its potential to improve survival.

Session: Session XVA: Papers 21-29: Parellel Session
Paper 28: 3:50-4:10 pm

OBSERVING PNEUMOTHORACES: THE 35 MM RULE IS SAFE FOR BOTH BLUNT AND PENETRATING CHEST TRAUMA

Savo Bou Zein Eddine MD, Kelly A. Boyle MD, Christopher M. Dodgion MBA,MD, MSPH, Christopher S. Davis MD,MPH, Travis P. Webb* MD, MHPE, Jeremy S. Juern* MD, David J. Milia MD, Thomas W. Carver* MD, Marshall A. Beckman MD, Panna A. Codner* MD, Todd A. Neideen* MD, Colleen Trevino Ph.D.,RN, FNP, Marc A. De Moya* MD, Medical College of Wisconsin

Invited Discussant: Andrew Kirkpatrick, MD

Introduction: As more pneumothoraxes (PTX) are being identified on chest computed tomography (CT), the appropriate management of observation versus tube thoracostomy (TT) remains debatable. We hypothesize that PTX measuring ≤35 mm on chest CT can be safely observed in both penetrating and blunt trauma mechanisms.

Methods: A retrospective review was conducted of all patients diagnosed with PTX by chest CT between January 2011 and December 2016. Patients were excluded if they had an associated hemothorax, had immediate tube thoracostomy (TT), or if a TT was done before the initial chest CT. PTXs were quantified by measuring the radial distance between the parietal and visceral pleura/mediastinum in a line perpendicular to the chest wall on axial imaging. Based on previous work, a cut-off of 35 mm on the initial CT was used to dichotomize the groups. Failure of observation was defined as the need for a delayed TT during the first week. A univariate analysis was performed to identify predictors of failure in both groups and multivariate analysis was constructed to assess the independent impact of PTX measurement on the failure of observation while controlling for demographics and chest injuries.

Results: Of the 1767 chest trauma patients screened, 832 (47%) had PTX and of those meeting inclusion criteria, 353 (92%) were successfully observed until discharge. Of those successfully observed, 335 (95%) patients had a measurement ≤ 35 mm. The negative predictive value for 35 mm as a cutoff was 94.9% to predict successful observation. In the univariant analyses, age ($p= 0.011$), rib fractures ($p= 0.012$), and size of the pneumothorax (≤35 mm or >35 mm) ($p< 0.0001$) were associated with failed observation. In multivariate analysis, PTX measuring ≤35 mm was an independent predictor of successful observation [OR 0.153, (95% CI: 0.061, 0.384)] for both blunt and penetrating trauma.

Conclusion: A 35 mm cut-off is safe as a general guide with only 5% of stable patients failing initial observation regardless of mechanism.

Session: Session XVA: Papers 21-29: Parellel Session
Paper 29: 4:10-4:30 pm

TO SLEEP, PERCHANCE TO DREAM: ACUTE AND CHRONIC SLEEP DEPRIVATION IN ACUTE CARE SURGEONS

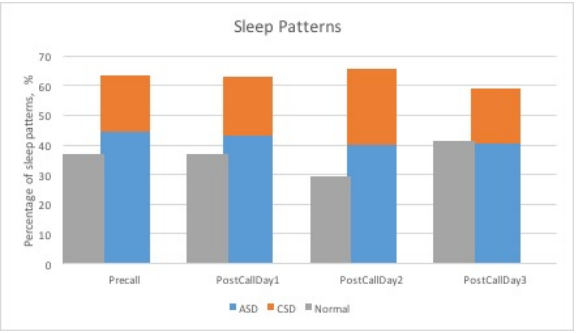
Jamie J. Coleman* MD, Ben L. Zarzaur* MD,MPH, Lava Timsina MPH,Ph.D., Grace S. Rozycki* MBA,MD, David V. Feliciano* MD, Indiana Univesity School of Medicine

Invited Discussant: Nicole Stassen, MD

Introduction: Acute and chronic sleep deprivation are significantly associated with depressive symptoms and felt to be contributors to the development of burnout. In-house call (IHC) inherently includes frequent periods of disrupted sleep and is common amongst acute care surgeons. The relationship between IHC and sleep deprivation amongst acute care surgeons has not been previously studied. The goal of this study was to determine prevalence and patterns of sleep deprivation in acute care surgeons.

Methods: A prospective study of acute care surgeons with IHC responsibilities from two ACS verified Level I trauma centers was performed. Participants wore a Whoop! fitness and sleep tracking device continuously over a 3-month period. Data collected included age, gender, schedule of IHC, hours and pattern of each sleep stage (light, slow wave, and REM), and total hours of sleep. Sleep patterns were also analyzed for each night excluding IHC and categorized as normal, acute sleep deprivation (ASD), or chronic sleep deprivation (CSD). Test of proportions for categorical and t-tests for continuous variables were done to identify any difference between pre and post-call days at 0.05 level of significance.

Results: A total of 1421 nights, including 230 nights of IHC, were recorded amongst 17 acute care surgeons (35.3% female; ages 37-65, mean of 45.5 years). Excluding nights of IHC, the average amount of sleep was 6.54 hours with 70% of nights with abnormal amounts of REM sleep, 56.4% with abnormal amounts of slow wave sleep, and 64.8% with sleep patterns categorized as ASD or CSD. The average amount of sleep was significantly higher than baseline on post-call day 1 (6.96 hours, p=0.0016), but decreased significantly on post-call day 2 (6.33 hours, p=0.0006) and returned to baseline on post-call day 3 (6.65 hours, p=0.274). Normal sleep patterns were significantly more prevalent on post-call day 3 as compared to post-call day 2 (p=0.045).



Conclusions: Sleep patterns consistent with ASD and CSD are common amongst acute care surgeons and worsen on post-call day 2. Baseline sleep patterns were not recovered until post-call day 3. Future study in a multicenter setting is needed to identify factors which impact physiologic recovery after IHC and further elucidate the relationship between sleep deprivation and burnout.

Session: Session XVB: Papers 30-38: Basic Science
Paper 30: 1:30-1:50 pm

DOES A LUNG INFECTION AFTER BRAIN INJURY WORSEN EARLY BRAIN INFLAMMATION AND SUBSEQUENT NEUROLOGICAL RECOVERY?

Christina L. Jacovides MD, Syed M. Ahmed MD, Yujin Suto MD,Ph.D., Andrew J. Paris MD, Ryan Leone Maura T. Weber BA, Victoria E. Johnson Ph.D., MBChB, Melpo Christofidou-Solomidou Ph.D., Lewis J. Kaplan* MD, Douglas H. Smith MD, Daniel N. Holena MD, MSCE, C W. Schwab* MD, Jose L. Pascual* MD,Ph.D., University of Pennsylvania

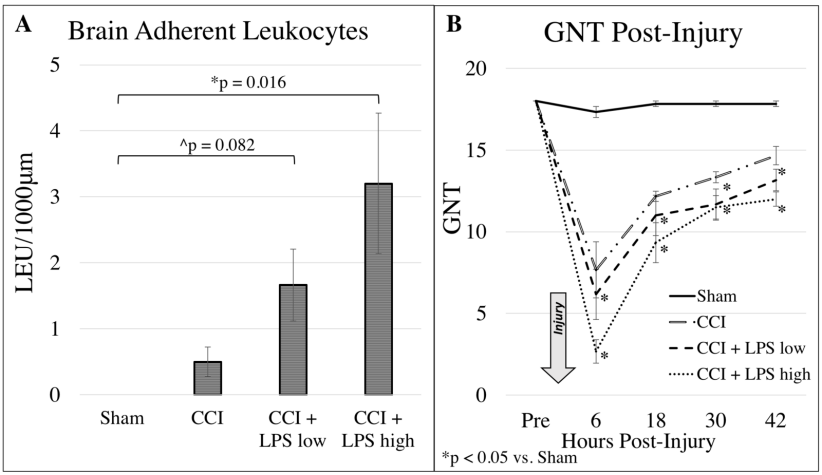
Invited Discussant: Deborah Stein, MD, MPH

Introduction: Respiratory complications after traumatic brain injury (TBI) worsen mortality and neurologic outcomes. How pulmonary infection influences active cerebral leukocyte (LEU)-mediated inflammation and resultant neurologic recovery is unknown. We hypothesized that an infection-relevant inflammatory lung insult after TBI increases penumbral LEU trafficking and worsens neurological recovery.

Methods: CD1 male mice underwent either sham craniotomy or severe TBI (controlled cortical impact – CCI: velocity=6m/sec, depth=1.0mm) ± intratracheal lipopolysaccharide (LPS – low: 0.3mg/kg in 0.02ml saline, high: 2mg/kg in 0.1ml saline). Randomization defined 4 groups (Sham, CCI, CCI+LPS low, CCI+LPS high, n=6/each). Neurological recovery (Garcia Neurological Test (GNT), max score=18) was assessed twice daily. Forty-eight hours after CCI, pial microscopy assessed *in vivo* cerebral circulating LEUs and bronchoalveolar lavage fluid was sampled for total LEU count. We used Kruskal-Wallis test with Bonferroni correction to determine intergroup differences ($p<0.05$).

Results: Animals exposed to high dose LPS following CCI demonstrated the greatest *in vivo* cerebral leukocyte adherence (Fig A) ($p=0.016$) and were significantly more neurologically impaired than sham animals at all post-injury time periods (Fig B) ($p<0.05$). While cerebral LEU rolling was similar across groups, alveolar LEU sequestration was greatest in LPS-exposed brain-injured animals ($p<0.05$).

Conclusion: An endotoxin-induced inflammatory lung insult after TBI focuses cerebral LEU trafficking to injured brain and is associated with impaired neurological recovery. LEU sequestration offers a mechanism to explain clinically relevant outcomes after TBI.



Session: Session XVB: Papers 30-38: Basic Science
Paper 31: 1:50-2:10 pm

ELECTROPORATION-MEDIATED LUNG GENE TRANSFER OF HUMAN FELINE SARCOMA RELATED (FER) TYROSINE-KINASE MOBILIZES TOLL-LIKE RECEPTOR-4 GRANULO-MONOCYTES AND IMPROVES SURVIVAL IN MURINE MODEL OF PSEUDOMONAS AERUGINOSA PNEUMONIA

David Machado-Aranda MD, Vladislav Dolgachev Ph.D., Matthew J. Delano* MD,Ph.D., MV Suresh Ph.D., Boya Zhang BS, Samatha Swamy Sanjay Balijepalli Lynn Frydrych MD, Mark R. Hemmila* MD, Krishnan Raghavendran* MD, University of Michigan

Invited Discussant: James Hoth, MD

Introduction: Infection from *Pseudomonas aeruginosa* is a leading cause of death among trauma patients. The increasing incidence of Colistin and Carbapenem-resistant strains has been compelled the WHO to declare *Pseudomonas* a threat to global health. As an innovative strategy, restoring and stimulating our immune system by using short-term gene therapy, could be of potential therapeutic value. A recent genome-wide association study showed that *Fe*line Sarcoma *R*elated (FER) a non-receptor protein tyrosine kinase of the Fes/fps family as protective in patients (including trauma) with sepsis. In proof of concept, we have shown that non-viral electroporation-mediated (EP) delivery of FER gene, can improve survival in murine models of primary and secondary *Klebsiella* pneumonia (PNA). We asked if this same benefit could be achieved against highly virulent *Pseudomonas*.

Methods: C57/BL6 female mice received 10^8 CFU of *Pseudomonas* clinical isolate via hypo pharyngeal drop injection into lungs. At 1 h, a 100 µg dose of naked plasmid encoding the human FER gene - was given by similar technique. After waiting several breaths; 8 square wave pulses were delivered at 200 V/cm strength; 10 ms duration and 1 s apart using a BTX ECM 830 generator with electrodes under each forelimb. Survival curves were recorded. In parallel, animals were euthanized at 24 h. The trachea was cannulated and a Bronchial-alveolar lavage (BAL) was obtained. Flow cytometry, ELISA and Taqman were used to characterize BAL cells and cytokines in supernatant. Naive and infected sham-EP were used as controls. A p value of < 0.05, in Log-rank testing (for KM curves) and one-way ANOVA (for all other data) was considered significant (N=10).

Results: Clinical isolate of *Pseudomonas aeruginosa* was highly virulent, showing significant lung damage at 48 hours. Nevertheless, EP-mediated delivery of FER gene improved 5-day survival (40% vs 10%, $p < 0.05$). At 24-h post-infection, FER treatment increased total cells in BAL by 2.5 fold ($p = 0.013$). Flow cytometry and cytospin slides showed a majority of cells belonging to Granulo-monocytic lineage, with Toll-like receptor-4 (TLR-4), a major pattern recognition molecule receptor against Gram-negatives, as a predominant surface marker. Additionally electroporation of FER showed higher levels of cytokines TNFα , IL-1β , IL-6 and KC in BAL, supporting a heightened response against *Pseudomonas* infection.

Conclusion: Though showing modest results in contrast to previously reported success against *Klebsiella* infection, EP mediated gene delivery of human FER gene was able to improve survival in a primary murine model of *Pseudomonas* pneumonia. This beneficial effect appears to be mediated by robust recruitment and enhanced mobilization of TLR-4-sensitized innate inflammatory cells into alveolar spaces and therefore adapted to fight off Gram-negative infections with possible acceleration of clearance of bacteria from the lung. This provides a promising avenue of research against multidrug resistant nosocomial organisms in trauma.

Session: Session XVB: Papers 30-38: Basic Science
Paper 32: 2:10-2:30 pm

RED BLOOD CELL STORAGE AND ADHESION TO VASCULAR ENDOTHELIUM UNDER NORMAL OR STRESS CONDITIONS: AN IN VITRO MICROFLUIDIC STUDY

Lawrence Diebel* MD, David M. Liberati MS Wayne State University

Invited Discussant: Rosemary Kozar, MD, PhD

Introduction: Observational studies have identified an association between duration of red blood cell (RBC) storage and adverse outcomes in trauma. Hemorrhagic shock (HS) leads to impaired tissue perfusion which is associated with endothelial cell (EC) injury and glycocalyx (GC) shedding. Adhesion of stored RBC to the vacular endothelium has been shown to lead to impaired perfusion in the microcirculation and contribute to organ failure and poor outcome following HS. The role of either or both of the EC and RBC glycocalyx in this process is unknown and was studied in a *in vitro* model.

Methods: Human umbilical vein endothelial cells (HUVEC) wer plated in a microfluidic device system (MDS) under perfusion for 72 hrs. to allow EC confluence and GC maturation. RBC obtained from human volunteers (fresh) or RBC obtained from the blood bank (< 14 day storage or < 21 day storage) at 1.5% suspension were added to the perfusate at increasing flow rates. In some experiments the HS microenvironment was simulated by hypoxia-reoxygenation (HR) + epinephrine (epi) during the perfusion experiments. EC and RBC glycocalyx were measured using fluorescein labeled wheat germ agglutinin and image analysis with a fluorescent microscope. RBC adhesion to the EC in the MDS under constant flow was determined by microscopy with progressively increasing shear rate to index RBC adherence strength.

Results:

	Glycocalyx (Fluorescent intensity)	RBC Adherence	
		HUVEC control	HUVEC + HR + epi
HUVEC control (N = 5)	265.3 ± 19.6	------	------
HUVEC + HR + epi (N = 5)	143.4 ± 18.5&	------	------
Fresh RBC (N = 3)	51,038 ± 400	50 ± 11	80 ± 15
RBC < 14 day storage (N = 6)	40,939 ± 425*	103 ± 18*	189 ± 21*
RBC > 21 day storage (N = 6)	24,996 ± 650*#	175 ± 26*#	271 ± 28*#

&p< 0.05 vs. HUVEC control; *p< 0.05 vs. fresh RBC; #p< 0.05 vs. < 14 day storage

EC glycocalyx thickness was 41.2 ± 6.8 nm for the control and was reduced to 13.9 ± 5.1 nm in the HUVEC + HR + epi group ($p<0.05$). A significant fraction of the RBC adherent to the EC surface at low shear stress remained attached as the shear stress was sequentially increased to 5.0 dyne/cm2, indicating firm adherence, especially in the "old" RBC + HUVEC + HR +epi group.

Conclusion: RBC storage duration and EC exposed to "shock conditions" decrease the glycocalyx layer of each entity.. These data may help explain some of the remaining discrepancies in the clinical studies regarding the effect of RBC storage duration in the trauma population. Our data suggest that GC degradation is a component of the RBC storage lesion. Transfusion of RBC, based on the status of the RBC and EC glycocalyx may guide future strategies in trauma. Additionally the MDS platform may offer a high throughput modality to study emerging therapies for the endotheliopathy of trauma.

Session: Session XVB: Papers 30-38: Basic Science
Paper 33: 2:30-2:50 pm

TRANEXAMIC ACID SUPPRESSES THE RELEASE OF MITOCHONDRIAL DAMPS AND REDUCES LUNG INFLAMMATION IN A MURINE BURN MODEL

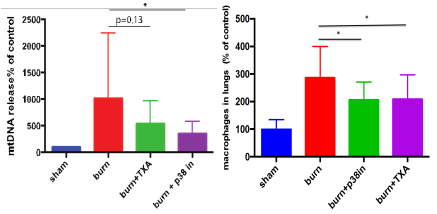
Damien W. Carter MD, Igor Prudovsky Ph.D., Doreen Kacer BS, Tee Soul BS, Monica Palmieri RN, Robert Kramer MD, Joseph Rappold* MD, Maine Medical Center

Invited Discussant: Carl Hauser, MD

Introduction: Severe burn injuries are known to initiate a profound systemic inflammatory response (SIRS) that may lead to burn shock and other SIRS related complications. Damage associated molecular patterns (DAMPs) are important early signaling molecules that initiate SIRS after burn injury. Mitochondrial DAMPs (mtDAMPs) – such as mitochondrial DNA (mtDNA) - are thought to be the most critical of these early signaling molecules. Previous work in a rodent model has shown that application of a topical immune modulator (P38 MAPK inhibitor) applied directly to the burn wound decreases cytokine expression, reduces pulmonary inflammation and edema. Our group has demonstrated that tranexamic acid (TXA) – in addition to its use as an anti-fibrinolytic – has anti-inflammatory in vitro effects. We hypothesized that administration of TXA after burn injury would attenuate mtDAMP release and reduce lung inflammation.

Methods: C57/BL6 male mice were subjected to a 40% TBSA scald burn by immersion in an 80°C water bath. Sham animals underwent the same procedure in room temperature water. All animals were resuscitated according to the Parkland formula (3cc x %TBSA x Weight [Kg]) by intraperitoneal injection (IP). One treatment group received the topical application of 1mM solution of p38 MAPK inhibitor after burn injury. The other treatment group received an IP administration of TXA (10 mg TXA per 25 g weight mouse) after burn injury. Animals were sacrificed at 4 or 8 hours. Plasma was collected by cardiac puncture. MtDNA levels in plasma were determined by qPCR. Lungs were harvested, formalin fixed and paraffin embedded. Sections of lungs were deparaffinized and stained for Mac1 antigen to detect macrophages. Numbers of macrophages per a standard square unit of lung section were calculated.

Results: Topical p38 MAPK inhibitor significantly attenuated mtDNA release while TXA trended toward a significant reduction in mtDNA release ($p \leq 0.13$). Both TXA and the topical p38 MAPK inhibitor significantly reduced lung inflammation as represented by decreased macrophage infiltration.



Conclusion:

Both p38 MAPK inhibitor and TXA demonstrated the ability to attenuate burn induced DAMP release and lung inflammation. Beyond its role as an anti-fibrinolytic, TXA may have significant anti-inflammatory effects pertinent to burn resuscitation. Further study is required; however, TXA may be a useful adjunct in burn resuscitation and other non-hemorrhagic shock states.

Session: Session XVB: Papers 30-38: Basic Science
Paper 34: 2:50-3:10 pm

ENDOTHELIAL CELL DYSFUNCTION DURING ANOXIA-REOXYGENATION IS ASSOCIATED WITH A DECREASE IN ATP LEVELS, REARRANGEMENT IN LIPID BILAYER PHOSPHATIDYLSERINE ASYMMETRY, AND AN INCREASE IN ENDOTHELIAL CELL PERMEABILITY

Javid Sadjadi* MD, Aaron M. Strumwasser MD, Gregory Victorino* MD, University of California San Francisco - East Bay

Invited Discussant: Timothy Pritts, MD

Introduction: Normanlly, phosphatidylserine (PS) is confined to the inner layer of the cell membrane (CM) and the maintenance of this PS asymmetry is an energy-dependent process. During times of stress PS is exteriorized on the CM. Because cellular stress is often accompanied by decreased energy levels and maintaining PS asymmetry is an energy-dependent process, cellular stress associated with decreased energy levels may be associated with PS exteriorization that ultimately leads to endothelial cell (EC) dysfunction and increased permeability. Anoxia-Reoxygenation (A-R) is associated with decreased adenosine triphosphate (ATP) levels, increased PS exteriorization on cells, and increased EC permeability.
Methods: : The effect on ATP levels of A-R was measured with cultured human umbilical vein endothelial cells (HUVECs). After exposure to anoxia or A-R, ATP levels were measured using a standard colorimetric assay from: 1) Controls , 2) Cells that underwent 45 minutes of anoxia, and 3) Cells that underwent anoxia followed by reoxygenation. To measure the effect of A-R on PS exteriorization, bovine pulmonary artery endothelial cells (BPAECs) and HUVECs underwent the A-R treatment as above. Cells were then incubated with annexin which binds to exposed CM PS, but not internal or unexposed PS. annexin fluorescence was read at 680nm. Next we were interested in the effect of A-R on total cell PS quantity, not just exteriorized PS. A-R was induced as described in BPAEC and HUVEC monolayers which were then treated with detergent to open the CM, thereby allowing annexin intracellular access and the ability to measure total PS. Finally, to measure EC permeability, monolayers of BPAECs and HUVECs were formed and confirmed by measuring resistance to confirm tight junction integrity. A-R was induced as described. The apical side of the cells was treated with either PBS (controls) or PBS with biotinylated-bovine serum albumen (BSA), while the basolateral surface contained normal medium. To measure the amount of leaked BSA, solution from the basolateral compartment underwent color reaction.
Results: ATP levels in HUVECs decreased 27% from baseline after 45 minutes of anoxia and decreased further from baseline by 63% after 45 minutes of anoxia followed by 240 minutes of reoxygenation ($p<0.02$). Exteriorized PS doulbed as compared to controls in both BPAECs ($p<0.01$), and HUVECs ($p<0.01$). We also found that during A-R, the total amount of cellular PS increased almost 2-fold in BPAECs ($p<0.01$), and nearly 3-fold in HUVECs ($p<0.01$). This finding that total PS changed 2-fold after A-R suggests that not only is there a change in distribution of PS from the inner to the outer CM, but there may also be an increase in the amount of PS inside the cell, either on the inner CM or within cytosol. Finally, compared to controls, A-R increased monolayer permeability 12-fold in BPAECs ($p<0.01$), and by 37% in HUVECs ($p<0.01$).
Conclusion: Taken together, these data support the idea that EC dysfunction during A-R is associated with: 1) a decrease in ATP levels, 2) PS exposure to the outer CM, 3) an increase in total cellular PS levels, and 4) an increase in monolayer permeability . These data strengthen the notion that PS arrangement in CMs play a critical role in the endothelial dysfunction during cellular stress and may hold the key to potential novel therapies for hemorrhagic shock and ischemia reperfusion injury.

Session: Session XVB: Papers 30-38: Basic Science
Paper 35: 3:10-3:30 pm

SELECTIVE AORTIC ARCH PERFUSION WITH FRESH WHOLE BLOOD OR HBOC-201 EFFECTIVELY REVERSES HEMORRHAGE-INDUCED TRAUMATIC CARDIAC ARREST IN A LETHAL MODEL OF NON-COMPRESSIBLE TORSO HEMORRHAGE

Heather E. Hoops MD, James E. Manning MD, Todd L. Graham BS, Belinda H. McCully Ph.D., Shane L. McCurdy BS, James D. Ross Ph.D., Oregon Health & Science University

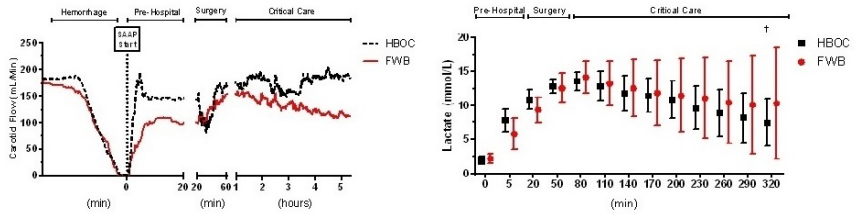
Invited Discussant: Samuel Tisherman, MD

Introduction: Hemorrhage-induced traumatic cardiac arrest (HiTCA) has a dismal survival rate. Previous studies demonstrated selective aortic arch perfusion (SAAP) with fresh whole blood (FWB) improved the rate of return of spontaneous circulation (ROSC) after HiTCA, compared to REBOA and CPR. Hemoglobin-based oxygen carriers, such as HBOC-201, may alleviate the logistical constraints of using FWB in a prehospital setting. It is unknown whether SAAP with HBOC-201 is equivalent in efficacy to FWB, whether conversion from SAAP to Extracorporeal Life Support (ECLS) is feasible, and whether physiologic derangement after HiTCA treated with SAAP therapy is reversible.

Methods: Twenty-six swine (79 ± 4kg) were anesthetized and underwent HiTCA which was induced via a grade V liver injury and controlled hemorrhage. Following 3 minutes of arrest, swine were randomly allocated to resuscitation using SAAP with either FWB (n = 12) or HBOC-201 (n = 14). After SAAP was initiated, animals were monitored for a 20-minute pre-hospital period prior to a 40-minute damage control surgery and resuscitation phase, followed by 260 minutes of critical care. Primary outcomes included rate of ROSC, survival, conversion to ECLS, and correction of physiology.

Results: Baseline physiologic measurements were similar between groups. ROSC was achieved in 100% (12/12) of the FWB animals and 86% (12/14) of the HBOC-201 animals (p = 0.483). Survival (t = 320 min) was 92% (11/12) in the FWB group and 67% (8/12) in the HBOC-201 group (p = 0.120), with 2 exclusions in the HBOC-201 group due to equipment failure. Conversion to ECLS was successful in 100% of both groups. Following hemorrhage, SAAP with HBOC-201 restored carotid flow (CF) to baseline levels at t=20min (p=0.302) and the end of the experiment (p=0.302), which was not seen with FWB (p=0.020, p=0.004). Lactate peaked at 80 minutes after arrest in both groups, and significantly improved by end of experiment in the HBOC-201 group (p = 0.001) but not the FWB group (p = 0.104).

Figure - Pooled data for carotid flow and serum lactate over time



Conclusion: SAAP is effective in eliciting ROSC after HiTCA in a swine model, using either fresh whole blood or HBOC-201. It is feasible to transition from SAAP to ECLS after definitive hemorrhage control, resulting in overall survival greater that 66% in both groups. The physiologic derangements were severe but reversible, with a carotid flow and lactate levels returning to baseline levels by endo of experiment in the HBOC-201 group, but not the FWB group.

Session: Session XVB: Papers 30-38: Basic Science
Paper 36: 3:30-3:50 pm

DOES BLOOD TRANSFUSION PRESERVE THE GUT MICROBIOME (GM) AFTER TRAUMA? A PROSPECTIVE, CLINICAL STUDY IN SEVERELY INJURED PATIENTS

Susannah E. Nicholson MD, MSCI, Taylor R. Johnson BS, David M. Burmeister Ph.D., Yi Zou Ph.D., Zhao Lai Ph.D., Shannon Scroggins MS, Mark DeRosa Rachelle B. Jonas RN, Daniel R. Merrill BS, Caroline Zhu Larry M. Newton MS, Ronald M. Stewart* MD, Martin G. Schwacha Ph.D., Donald H. Jenkins* MD, Brian J. Eastridge* MD, University of Texas Health Science Center at San Antonio

Invited Discussant: Mitchell Cohen, MD

Introduction: Traumatic injury can lead to a compromised intestinal epithelial barrier, inflammation and immune derangements. The impact of trauma on gut microbial composition is unknown. Alterations in the GM of the critically injured may contribute to infectious or inflammatory complications and influence clinical outcomes. Our objective was to determine if the gut microbiome is altered in severely injured patients and to characterize the microbial composition of the gut over time following trauma.

Methods: We conducted a prospective, observational study in adult patients (n=72) sustaining severe injury admitted to a Level I Trauma Center. Healthy volunteers (n=13) were also enrolled. Fecal specimens were collected on admission to the Emergency Department (ED) and at 1, 3, and 7 days (±2 days) following injury. Microbial DNA was isolated from all fecal samples for 16s rRNA sequencing. GM analysis and taxonomic classification were performed using the QIIME Greengenes 16S rRNA gene database (OTUs; 97% similarity). Alpha and β-diversity were estimated using the observed species metrics.

Results: Characteristics of our study population are shown in Table 1. The GM profile was altered within 30 minutes following injury compared to healthy volunteers (Fig. 1). Patients with an unchanged GM on admission arrived to the ED faster and were transfused more RBCs than those with an altered GM (Table 1). The GM composition among the majority of subjects returned to a profile similar to the healthy volunteers by Day 5. Despite the observed trends in the β-diversity, the total number of species was similar between admission and healthy samples but decreased over time thereafter, signifying loss of α-diversity during hospitalization. Injured patients on admission had a decreased abundance of traditionally beneficial microbial families compared to healthy controls ($p<0.05$). In contrast, an increased abundance in opportunistic families in the injured patients was noted on admission compared to healthy controls ($p< 0.05$).

Conclusion: The human GM changes as early as 30 minutes following injury with additional dysbiosis occurring during the hospital stay. The GM in patients receiving large quantities of RBCs was preserved on admission suggesting a potential protective effect on microbial profile by reducing gut ischemia. Ultimately, the GM of trauma patients may provide valuable diagnostic and therapeutic strategies for the improvement of outcomes post-injury.

	Control	Total	GM Changed	GM Not Changed	p value
# of subjects	13	72	52 (72%)	20 (28%)	
Age	43	44	45	43	0.89
# of Females	6 (46%)	25 (35%)	17 (33%)	6 (30%)	0.23
# of Blunt		57 (79%)	42 (81%)	15 (75%)	0.58
# of Penetrating		15 (21%)	10 (19%)	5 (25%)	0.58
ISS		21	20	22	0.34
Shock Index		0.95	1.02	0.84	0.18
RBCs (units)		6	3	10	0.0002
Transport Time (min)			28	24	<0.0001

Table 1. Characteristics of our study population reported as means (percentages). Shock Index refers to heart rate divided by systolic blood pressure. Transport time is the time (min) taken to transport patients from the scene until arrival in the ED. Units of RBCs transfused were significantly higher, and transport time was significantly lower in patients whose GM was not different than healthy controls.

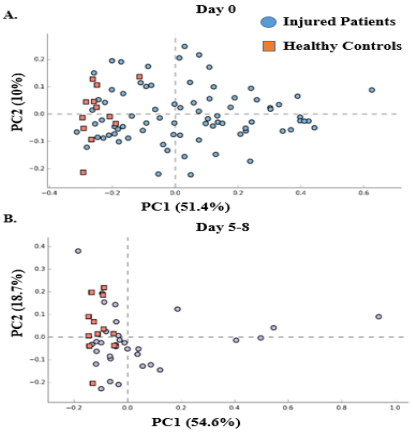


Figure 1. A. Principle components analysis (PCA) of injured patients on Day 0 (blue) compared to healthy controls (red) reveals 2 distinct GM characteristics. B. PCA of injured patients on Day 5-8 (blue) compared to controls (red).

Session: Session XVB: Papers 30-38: Basic Science
Paper 37: 3:50-4:10 pm

PRECIOUS CARGO: NEURO-ENTERIC MODULATION OF THE MESENTERIC LYMPH EXOSOME PAYLOAD AFTER HEMORRHAGIC SHOCK

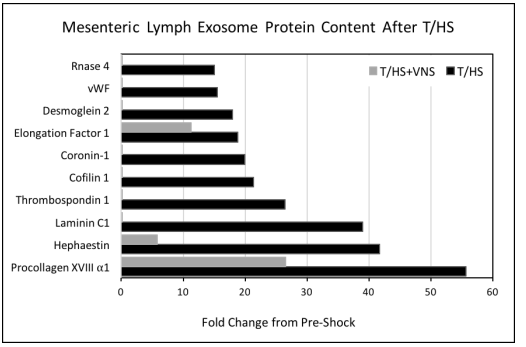
Elliot C. Williams MD, Raul Coimbra* MD, Theresa W. Chan MD, Andrew Baird Ph.D., Brian Eliceiri Ph.D., Todd W. Costantini* MD, University of California, San Diego

Invited Discussant: Jason Smith, MD

Introduction: Trauma/hemorrhagic shock (T/HS) causes a release of pro-inflammatory mediators into the mesenteric lymph (ML) that triggers a systemic inflammatory response and can result in organ failure. Recently we showed that exosomes in post-shock ML are biologically active mediators of this inflammation, but the specific inflammatory mediators in post-shock ML exosomes have yet to be characterized. To this end, we hypothesized that T/HS leads to production of a distinct ML pro-inflammatory exosome phenotype that could be identified by mass spectrometry analysis of exosome proteins. We further hypothesized that their regulation by the neuro-enteric axis via the vagus nerve would modify this pro-inflammatory profile.

Methods: Male rats underwent cannulation of the femoral artery, jugular vein, and ML duct. T/HS was induced by laparotomy and 60 minutes of HS (mean arterial pressure 35 mm Hg) followed by resuscitation with shed blood and two times shed blood volume of normal saline. ML was collected for 1 hour before HS (pre-shock) and for two hours after resuscitation (post-shock). A subset of animals underwent cervical vagus nerve electrical stimulation (VNS) immediately after the HS phase. Ultra-high-pressure liquid chromatography with tandem mass spectroscopy (LC-MS/MS) followed by protein identification and label free quantification was performed on exosomes from the pre-shock and post-shock phases in the T/HS and T/HS+VNS groups.

Results: Seven hundred and forty-three unique proteins were identified in ML exosomes from T/HS rats. Thirty-three proteins were found to be statistically significantly increased in exosomes in the post-shock phase relative to pre-shock (see Figure). Procollagen type XVIII (Col18a1, 56-fold), Hephaestin (Heph, 42-fold), Laminin C1 (Lamc1, 39-fold), and Thrombospondin 1 (Thbs1, 26-fold) showed the greatest increase in ML exosomes after T/HS. Gene Ontology analysis of the increased proteins revealed significant functional enrichments in the "Response to Stress" biological process in the T/HS group. Stimulation of the vagus nerve following injury attenuated the T/HS-induced inflammatory phenotype of ML exosomes, with protein expression similar to pre-shock and no significant enrichments in Gene Ontology analysis.



Conclusion: The protein payload of ML exosomes changes after T/HS with an increase in proteins involved in the response to stress. Stimulating the neuro-enteric axis alters the biological activity of ML exosomes by attenuating this change.

Session: Session XVB: Papers 30-38: Basic Science
Paper 38: 4:10-4:30 pm

ACUTE RESUSCITATION WITH POLYETHYLENE GLYCOL-20K: A THROMBOELASTOGRAPHIC ANALYSIS

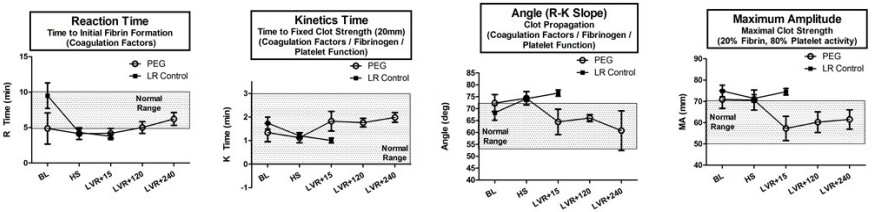
Niluka A. Wickramaratne BS,MD, Kristine Kenning MD, Heather Reichstetter LVT, Charles Blocher MS, Ru Li Ph.D., Michel Aboutanos* MD,MPH, Martin Mangino Ph.D., Virginia Commonwealth University

Invited Discussant: Jeremy Cannon, MD

Introduction: Polyethylene glycol-20,000Da (PEG-20k) is a synthetic polymer with impermeant and colloidal properties that is highly effective for resuscitation in animal models of shock. Its proposed mechanism involves prevention of metabolic swelling by energy independent osmotic water transfer, moving water out of the cell and into the capillary space. In rodents, PEG-20k increases tolerance to the shocked state after severe hemorrhage by 6-8 fold compared to controls. However, thromboelastography (TEG) showed an abnormal hypocoagulable effect on human blood that was treated ex-vivo with a 10% volume dose of PEG-20k. The objective of this study was to determine the in-vivo effects of PEG-20k on coagulation and peak plasma levels in a preclinical porcine model of hemorrhagic shock. We hypothesize that any coagulation effect of PEG-20k will be dependent on the peak blood levels after resuscitation.

Methods: Anesthetized juvenile Yorkshire pigs underwent femoral vessel cannulation and laparotomy to simulate soft tissue trauma. They were then hemorrhaged (MAP held 30-40 mmHg) until either the lactate reached 7 mmol/L, 115 minutes of hemorrhage time had passed, or 50-55% of their estimated blood volume (EBV) was removed. The pigs then underwent low volume resuscitation (LVR) with either a 10% PEG-20k solution (100mg/ml) containing a FITC-labelled PEG-20k marker or Lactated Ringers (LR) as a control (n=5 in each group), both delivered at a volume equal to 10% of the EBV. Whole blood TEG analysis was performed after the surgery (baseline, BL), after hemorrhage (HS), and 15, 120, and 240 minutes (LVR+15, 120, 240) after resuscitation, if the animals survived that long. Plasma samples were serially collected after resuscitation and plasma PEG-20k concentration was determined by fluorescence indicator dilution. Other outcomes included survival time. Of note, all studies were arbitrarily terminated at 240 minutes due to the acute nature of the experiment.

Results: Pigs given low volume resuscitation with PEG-20k were able to survive 3 times longer than LR volume controls ($p<0.001$). This was a marked underestimation because of termination at 240 minutes in the PEG group. Coagulation and platelet function analysis using TEG was limited to the 15 minute post-resuscitation time point in the control group due to lack of survival. Trauma and hemorrhage induced a slightly hypercoagulable state on individual TEG parameters, R Time, K Time, Angle, and Maximum Amplitude (MA). However, these normalized after LVR with PEG-20k, but not LR (Figure). For example, the Coagulation Index (CI), which is a compilation of R, K, Angle, and MA, rose to an average of 3.3 (normal -3 to 3) after hemorrhage in both groups, but normalized to 0.1 fifteen minutes after PEG-20k administration. The CI continued to rise to 4.8 fifteen minutes after LVR with LR alone. The plasma concentration of PEG-20k peaked at an average of 3.58 mg/ml and had a half-life of 138 minutes. The peak plasma concentration was 3-fold lower than predicted by simple dilution (10 mg/ml), which is likely responsible for the lack of abnormal TEGs after in-vivo PEG-20k administration.



Conclusion: These data demonstrate that acute resuscitation with PEG-20k not only improves tolerance to hypovolemia but also normalizes the initial hypercoagulative state of trauma and shock. Although PEG-20k may interfere with coagulation and platelet function, when given at an effective dose for resuscitation, it does not induce a hypocoagulable TEG profile due to much lower in-vivo plasma concentrations than predicted.

Session: Session XVIII: Papers 39-44: Coagulation
Paper 39: 7:30-7:50 am

MICROVESICLES GENERATED FOLLOWING TRAUMATIC BRAIN INJURY INDUCE PLATELET DYSFUNCTION VIA ADP RECEPTOR

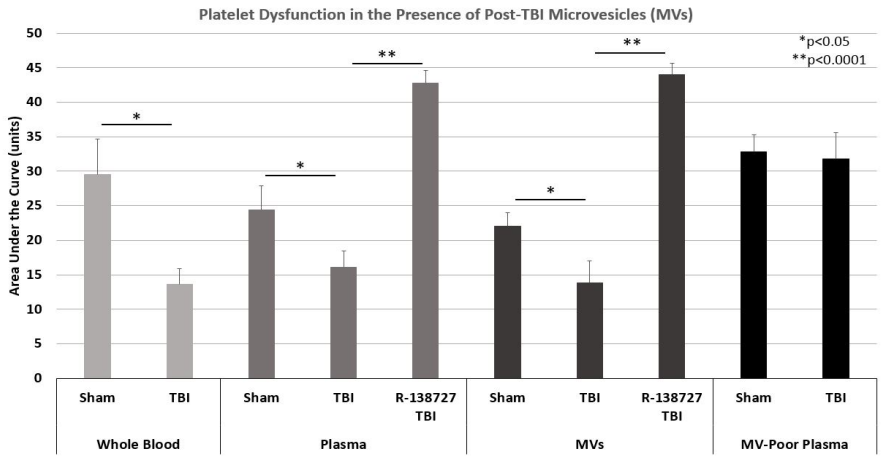
Grace E. Martin MD, Amanda Pugh MD, Rose Veile BS, Lou Ann Friend RVT, Amy T. Makley MD, Charles C. Caldwell Ph.D.,
Timothy A. Pritts* MD,Ph.D., Michael D. Goodman MD, University of Cincinnati

Invited Discussant: John Holcomb, MD

Introduction: Traumatic brain injury (TBI) can result in an acute coagulopathy including platelet dysfunction that can contribute to ongoing intracranial hemorrhage. Previous clinical studies have shown ADP-induced platelet aggregation to be reduced after TBI. In addition, circulating microvesicles are increased following TBI and have been shown to play a role in post-TBI coagulopathy. We hypothesized that post-TBI microvesicles would affect platelet aggregation in a murine head injury model.

Methods: Moderate concussive TBI was performed using an established weight-drop method in anesthetized mice. Sham mice underwent anesthesia without TBI. Whole blood, plasma, microvesicles, and microvesicle-poor plasma were isolated from blood collected 10 minutes following TBI or sham. Post-TBI plasma, microvesicles, and microvesicle-poor plasma were mixed separately with whole blood from uninjured mice. Platelet aggregation was measured with Multiplate impedance platelet aggregometry in response to arachidonic acid and adenosine diphosphate (ADP). Platelet contribution to maximum clot formation was calculated using the rotational thromboelastometry extrinsically-activated and fibrin-based extrinsically activated tests. Normal saline was used as a dilution control. The ADP P2Y$_{12}$ receptor inhibitor, R-138727 (100uM, prasugrel active metabolite), was incubated with plasma and microvesicles from post-TBI mice, and platelet inhibition was again measured. To confirm P2Y$_{12}$ presence in post-TBI microvesicles, Western blots were performed and analyzed using densitometry.
Results: Whole blood taken from 10 minute post-TBI mice demonstrated diminished ADP-induced platelet aggregation compared to sham mice (13.6 ± 2.3 vs. 29.5 ± 5.2 units, $p<0.01$). When mixed with normal donor blood, post-TBI plasma induced diminished ADP-induced platelet aggregation compared to sham plasma (16.1 ± 2.3 vs. 24.4 ± 3.5 units, $p<0.05$). The addition of post-TBI microvesicles to uninjured whole blood similarly reduced ADP-induced platelet aggregation compared to sham microvesicles (13.8 ± 3.2 vs. 22.0 ± 2.0 units, $p<0.05$). By contrast, the addition of microvesicle-poor post-TBI plasma to normal blood did not change ADP-induced platelet aggregation and was not different compared to sham microvesicle-poor plasma (31.8 ± 3.8 vs. 32.8 ± 2.5 units, $p>0.9$). No differences were observed in the ability of arachidonic acid to induce platelet aggregation. Thromboelastometry demonstrated no difference in the platelet contribution to maximum clot formation after addition of sham and post-TBI microvesicles. The observed dysfunction in post-TBI ADP platelet aggregation was prevented by the pretreatment of post-TBI plasma with 100uM R-138727 (46.8 ± 1.5 units, $p<0.0001$ compared to post-TBI plasma). Treatment of post-TBI microvesicles with R-138727 resulted in similar findings of improved ADP-induced platelet aggregation compared to non-treated post-TBI microvesicles (42.8 ± 1.8 units vs. 13.8 ± 3.2 units, $p<0.0001$). Inhibition of ADP-induced platelet aggregation was also was mitigated by freezing the post-TBI microvesicles prior to whole blood treatment (44.0 ± 1.7 units frozen vs. 13.8 ± 3.2 units fresh, $p<0.0001$). Western blots of post-TBI microvesicles demonstrated the presence of the ADP P2Y$_{12}$ receptor.

Conclusion: ADP-induced platelet aggregation is inhibited acutely following TBI in a murine model. This platelet inhibition is reproduced in normal blood by the introduction of post-TBI plasma and microvesicles. Furthermore, platelet inhibition is abrogated by post-TBI plasma and microvesicle treatment with an inhibitor of the P2Y$_{12}$ ADP receptor. Clinically observed post-TBI platelet dysfunction may therefore be explained by the presence of the ADP P2Y$_{12}$ receptor within post-TBI microvesicles and may represent a future therapeutic target for TBI patients.



Session: Session XVIII: Papers 39-44: Coagulation
Paper 40: 7:50-8:10 am

GUIDELINE-BASED CORRECTION OF PLATELET INHIBITION IN TBI PATIENTS IS ASSOCIATED WITH IMPROVED MORTALITY

Andrew B. Sorah MD, Kyle Cunningham MD, Colleen Karvetski Ph.D., Michael Ekaney Ph.D., Rita Brintzenhoff MD, Susan Evans* MD, Carolinas Medical Center

Invited Discussant: Michael Cripps, MD

Introduction: Platelet dysfunction has been demonstrated following traumatic brain injury (TBI) regardless of the use of platelet inhibitors. The purpose of this study is to determine the efficacy of a platelet mapping thromboelastography (PM-TEG) based guideline in predicting traumatic brain injury (TBI) patients who would benefit from platelet transfusion. We hypothesized that adenosine diphosphate (ADP) and Arachadonic Acid (AA) inhibition in patients with TBI is associated with increased mortality and can be corrected with platelet transfusion.

Methods: This is a retrospective review of patients admitted to a Level I trauma center from January 2016 through September 2017 with moderate to severe TBI (msTBI), defined by an initial GCS ≤13 with intracranial hemorrhage. According to our guideline, patients with msTBI receive PM-TEG. Those patients who demonstrate platelet dysfunction (either ADP or AA inhibition ≥60%) receive 1 apheresis pack of platelets followed by repeat PM-TEG, until inhibition <60% or maximum 3 packs of platelets transfused. Cohorts were defined as patients without (NPI) and with (PI) platelet inhibition, and subdivided into those whose inhibition corrected after transfusion (PI-C) versus those whose inhibition did not correct (PI-NC). Outcome variables (mortality, length of stay (LOS), and venous thromboembolism (VTE) were compared for all groups. Patient age, APACHE IV Score and ISS were utilized for risk adjustment.

Results: A total of 240 patients received PM-TEG during the timeframe of the study; NPI n= 85, PI-NC n= 39, PI-C n= 36. Patients who did not receive f/u PM-TEG result after transfusion were excluded from analysis n=26. Patients who were inhibited at baseline, but did not receive platelets (n= 54) were included as a subgroup in the analysis. Platelet inhibition was associated with increased mortality (PI = 43.2% vs. NPI = 29.4%), with a 1.8x increased likelihood of mortality after controlling for ISS and age (p=0.05). There was no difference in LOS among survivors between the inhibited and non-inhibited groups (NPI = 14(8,29) vs. PI=18(12,27); p=0.48). Among patients with platelet inhibition at baseline, mortality was greater if platelet transfusion did not result in correction of inhibition (PI-NC = 56.4% vs. PI-C = 22.2%) with an OR of death = 4.8 after adjusting for age and ISS (p=0.006; 95% CI [1.6,14.4]). In addition, the subset of patients who were inhibited at baseline but did not receive platelets had a mortality rate twice that of patients who were transfused and corrected (44.4% vs 22.2%), with an OR of 3.6 [1.3,11.5] after correcting for ISS and age (p=0.02). LOS among survivors and rate of VTE were not different between these groups.

Condition	N	Mortality Rate (%)	Predicted Hospital Mortality (%) (APACHE)	Mortality O/E (APACHE)	APACHE Score (avg;SD)	ISS (avg;SD)	Age (avg; SD)	VTE	LOS among survivors (median;[IQR])
Not Inhibited at Baseline	85	29.4	31.1 (18.8)	0.99 (n=75)	75.1 (23.9)	25 (11)	47 [36,63]	0 (0.0%)	14 [8,29]
Inhibited, no platelets	54	44.4	32.6 (20.5)	1.25 (n=49)	78.0 (24.9)	25 (12)	44 [29,64]	1 (1.9%)	14 [7,22]
Inhibited, platelets, not corrected in protocol	39	56.4	38.7 (23.5)	1.38 (n=34)	85.3 (27.3)	32 (14)	47 [26,62]	0 (0.0%)	23 [18,33]
Inhibited, platelets, corrected in protocol	36	22.2	27.9 (14.2)	0.92 (n=28)	76.1 (19.9)	29 (14)	41 [29,54]	3 (8.3%)	17 [14,29]

Conclusion: Platelet inhibition in patients with moderate to severe TBI is associated with higher mortality and guideline directed correction of platelet inhibition is associated with improved survival. Additional study of the mechanisms involved in this association is warranted. A multicenter trial utilizing this guideline would aid in external validation.

Session: Session XVIII: Papers 39-44: Coagulation
Paper 41: 8:10-8:30 am

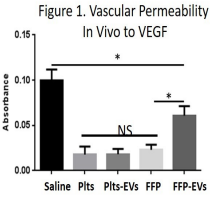
Platelet Derived Extracellular Vesicles are Equivalent to Platelets with Respect to Hemostasis and Vascular Permeability

Shibani Pati MD,Ph.D., Byron Miyazawa BS, Daniel R. Potter Ph.D., Ernesto E. Lopez MD, Amit K. Srivastava Ph.D., Charles E. Wade* Ph.D., Martin A. Schreiber* MD, John B. Holcomb* MD, University of California, San Francisco

Invited Discussant: Susan Evans, MD

Introduction: Platelet extracellular vesicles (Plt-EVs) have the potential to alleviate the logistical difficulties associated with platelet transfusion. Plt-EVs are membrane vesicles (50-1000nm) which are shed from platelets. Plt-EVs can be stored frozen and have demonstrated hemostatic properties. Circulating platelets, in addition to hemostasis, function to stabilize the vasculature and inhibit endothelial cell (EC) permeability. We hypothesized that Plt-EVs would have therapeutic effects on permeability similar to fresh platelets and plasma (FFP). To investigate this hypothesis we used *in vitro* and *in vivo* models of vascular endothelial compromise and bleeding.

Methods: ***In vitro:*** EVs from FFP and platelets were isolated by ultracentrifugation. EVs were characterized for platelet markers (CD41b and CD62P) by flow cytometry. Human lung microvascular endothelial cells (HMVEC-L) were utilized for assessment of endothelial barrier function by changes in trans-EC electrical resistance (TEER). ECs were treated with Plts (25 X10 ^{3}/ml), Plt-EVs and FFP-EVs (70 µg/ml) and FFP (2%). EC tight junction breakdown induced by thrombin was assessed by staining for VE-Cadherin. ***In vivo*:** *Vascular Permeability:* A Miles assay was used to study the effects of the test groups on permeability induced by VEGF-A in immunodeficient NOD-SCID mice (n=5 mice/group). Mice were injected with test sample: 200 µl saline, Plts (3 X10^8), Plt-EVs (30 µg), FFP (200 µl) and FFP-EVs (30 µg). VEGF-A was injected in the dorsal skin to induce vascular leak of Evan's blue dye (EBD) which was quantitatively assessed. *Bleeding Model:* Tail snip assays in NOD-SCID mice were conducted with the same test groups (n=5 mice/group). Blood loss was measured. Statistical significance between groups was determined in all studies via one way ANOVA post hoc tukey tests.



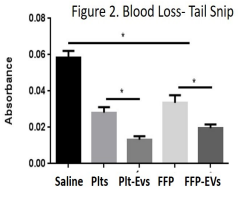


Figure 1. Miles assay NSG mice- Platelet Extracellular Vesicles (Plt-Evs) decreased vascular permeability similar to Fresh Platelets. **Figure 2**. Tail snip model of blood loss. Plt-Evs demonstrate superior hemostatic function compared to Plts. * indicates p<0.05.

Results: ***In vitro***: Flow cytometry confirmed that 90% of the Plt-EVs and FFP-EVs were of platelet origin. Plts and Plt-EVs both decreased EC monolayer permeability and restored EC tight junctions after thrombin challenge similar to FFP. Area under the curve measurements of TEER reveal that Plts and FFP are potent inhibitors of permeability and their EVs also decrease permeability (Resistance readings of the EC monolayer: Control: 0.69 ± 0.0067, Plts: 0.82 ± 0.029, FFP: 0.85 ± 0.0051, Plts-EVs: 0.74 ± 0.0038, FFP: 0.73 ± 0.026). All groups statistically increase TEER compared to control. ***In vivo:*** In a Miles assay of vascular leak**,** we observed that Plts, FFP and Plt-EVs have similar inhibitory effects on vascular permeability (**Figure. 1**). In the tail snip bleeding assay, we found that Plt-EVs decreased blood loss and demonstrated superior hemostatic properties compared to Plts and FFP **(Figure 2**).

Conclusion: Plt-EVs can be important for achieving hemostasis and attenuating vascular permeability in trauma. These findings indicate that Plt- EVs may be used in lieu of Plts and provide a novel product that is logistically superior for transfusion in diverse settings.

Session: Session XVIII: Papers 39-44: Coagulation
Paper 42: 8:30-8:50 am

Tranexamic acid as a risk factor for post-traumatic venous thromboembolism: results from a propensity matched cohort study

Sara P. Myers MD, MA, MS, Matthew E. Kutcher* MD, Matthew R. Rosengart* MD,MPH, Jason L. Sperry* MD,MPH, Joshua B. Brown* MD, MSc, Matthew D. Neal* MD, University of Pittsburgh

Invited Discussant: Adrian Maung, MD

Background: Trauma remains a leading cause of mortality worldwide. Hemorrhage control addresses the primary cause of early preventable deaths: bleeding. Tranexamic acid (TXA) is used as a hemostatic adjunct, but may promote serious complications such as venous thromboembolic (VTE) disease. Previous studies investigating the effect of TXA on VTE vary in their findings and the population of interest. We aim to investigate the association between TXA and VTE through a propensity matched retrospective cohort analysis, hypothesizing that TXA is an independent risk factor for VTE.

Methods: We conducted a retrospective study of all trauma patients presenting to a single level I trauma center during the period January 2012 to December 2016 to determine the association between TXA and risk of VTE. Our primary outcome was composite pulmonary embolus or deep vein thrombosis. Secondary outcomes included mortality, transfusion requirement, ICU length of stay, and hospital length of stay. We analyzed the data using a propensity matched mixed effects multivariate logistic regression to determine the adjusted odds ratio (aOR) and 95% confidence intervals (95% CI) of the association between TXA and our outcomes of interest, adjusting for differences in prespecified confounders. A competing risks regression model was used to determine subdistribution hazard ratio (SHR) of VTE after accounting for mortality as a competing risk. A p-value <0.05 was considered significant.

Results: A total of 189 matched pairs were included from a population of 21,931 patients. Subject pairs were well matched across propensity score variables (standardized differences <0.1). Median ISS was 19 (IQR 12, 27) in the TXA group, and 14 (IQR 8,22) in the non-TXA group (p=0.41). TXA was associated with more than 3-fold increase in the odds of VTE (aOR 3.3; 95%CI 1.3-9.1, p=0.02). TXA was not associated with survival (aOR 0.86; 95%CI 0.23-3.25, p=0.827). Risk of VTE remained elevated in patients treated with TXA despite accounting for mortality as a competing risk (SHR 2.42; 95% CI 1.11-5.29, p=0.027). Patients who received TXA experienced longer ICU (9.4 vs. 6.5 days, p<0.001) and hospital length of stays (18.2 vs. 10.9 days, p<0.001).

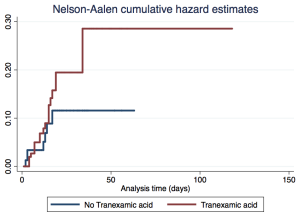
Conclusion: TXA may be an independent risk factor for VTE development without conferring survival benefit. Future investigation is needed to identify which injured patients have a survival advantage from TXA, especially given the risks of this intervention, to allow a more individualized treatment approach that maximizes benefits and mitigates potential harms.

Table 1: Characteristics of treated and untreated matched patients.

Characteristic	Treated N=189	Untreated N=189	p-value
Age, median (IQR)	36 (24-53)	32 (22-55)	0.33
Female, n (%)	47 (25%)	57 (30%)	0.23
HR (bpm), median (IQR)	130 (114, 141)	119 (104, 132)	0.41
SBP (mm Hg), median (IQR)	83 (70, 98)	84 (71-98)	0.95
ISS, median (IQR)	19 (12, 27)	14 (8, 22)	0.19
Hemoglobin (g/dL), median (IQR)	9 (7.5, 10.9)	8.6 (7.2,10.8)	0.50
Unadjusted survival, n (%)	136 (72%)	161 (85%)	0.04

N= total number of patients within a cohort; n= number of patients with baseline characteristic; IQR= interquartile range; HR= heart rate; bpm= beats per minute; SBP= systolic blood pressure; ISS= injury severity score; CI= confidence interval; VTE= venous thromboembolic event.

Figure 1: Cumulative hazards estimates of venous thromboembolic events among patients who received tranexamic acid compared to those who did not.



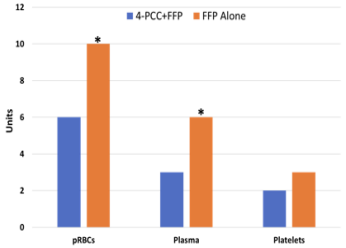
Session: Session XVIII: Papers 39-44: Coagulation
Paper 43: 8:50-9:10 am

4-FACTOR PROTHROMBIN COMPLEX CONCENTRATE IMPROVES SURVIVAL IN TRAUMA: A NATIONWIDE PROPENSITY MATCHED ANALYSIS

Muhammad Zeeshan MD, Mohammad Hamidi MD, Lynn Gries Muhammad Khan MD, Ara J. Feinstein* MD, Joseph Sakran* MD,MPH, Terence O'Keeffe* MD, Narong Kulvatunyou* MD, Bellal Joseph* MD, University of Arizona - Tucson

Invited Discussant: Matthew Martin, MD

Introduction: Post-traumatic hemorrhage or Exsanguination is the most common preventable cause of death in trauma patients. Numerous small single-center studies have shown that 4-PCC+FFP is superior to FFP alone in the resuscitation of trauma patients. The aim of our study was to evaluate outcomes of severely injured trauma patients who received 4-PCC+FFP compared to FPP alone.
Methods: We performed a 2-year (2015-2016) retrospective analysis of the ACS-TQIP. All adult (age≥18y) trauma patients who received 4-PCC+FFP or FFP alone were included. We excluded patients who were on preinjury anticoagulants. Patients were stratified into two groups: 4-PCC+FFP vs. FFP alone and were matched in a 1:1 ratio using propensity score matching for demographics, ED vitals, injury parameters, and hemorrhage control intervention. Outcome measures were pRBC, plasma & platelets units transfused, thromboembolic complications, and mortality.
Results: We analyzed 593,818 trauma patients, of which 118,940 patients met inclusion criteria. A total of 468 patients (4-PCC+FFP: 234, FFP alone: 234) were matched. The mean age was 50±21y; 70% were males, median ISS was 27 [20–36], and 87% had blunt injuries. 4-PCC+FFP was associated with a decreased requirement for pRBC units (6 units vs. 10 units; p=0.02) and FFP transfusion (3 units vs. 6 units; p=0.01) compared to FFP alone (**Fig 1**). There was no difference in the rates of thromboembolic complications; namely DVT (p=0.11) & PE (p=0.33), between the two groups (**Table 1.**). Patients who received 4-PCC+FFP had lower mortality (17.4% vs 27.7% p=0.01) **Fig 2**.
Conclusion: Our study demonstrates that the use of 4-factor PCC as an adjunct to FFP is associated with improved survival and reduction in transfusion requirements compared to FFP alone in the resuscitation of severely injured trauma patients. Further studies are required to evaluate the potential role of the addition of PCC to massive transfusion protocols.



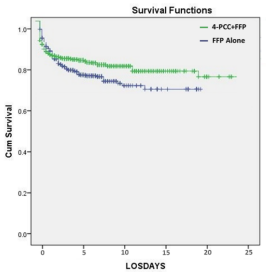


Table 1. Outcomes

Variables	4-PCC+FFP (n=234)	FFP alone (n=234)	*P-value*
Blood products			
pRBC transfused, units	6 ± 4	10 ± 4	0.02
FFP, units	3 ± 2	6 ± 3	0.01
Platelets, units	2 ± 3	3 ± 3	0.72
Thromboembolic complications			
DVT	3.6%	5.5%	0.11
PE	1.1%	1.8%	0.33
SNF/Rehabilitation	39.1%	38.4%	0.21
Mortality	17.4%	27.7%	0.01

INR = International Normalized Ratio, PRBC = Packed Red blood cells, FFP = fresh frozen plasma, DVT = Deep venous thrombosis, PE = Pulmonary embolism.

Session: Session XVIII: Papers 39-44: Coagulation
Paper 44: 9:10-9:30 am

DESMOPRESSIN IS A TRANSFUSION SPARING OPTION TO REVERESE PLATELET DYSFUNCTION IN PATIENTS WITH SEVERE TRAUMATIC BRAIN INJURY

Elisa Furay MD, Mitchell J. Daley PharmD, Praveen N. Satarasinghe BS, Pedro Teixeira MD, Thomas B. Coopwood* MD, Marc D. Trust MD, Jayson D. Aydelotte MD, Carlos V. Brown* MD, Dell Seton Medical Center
At The University Of Texas

Invited Discussant: Susan Rowell, MD

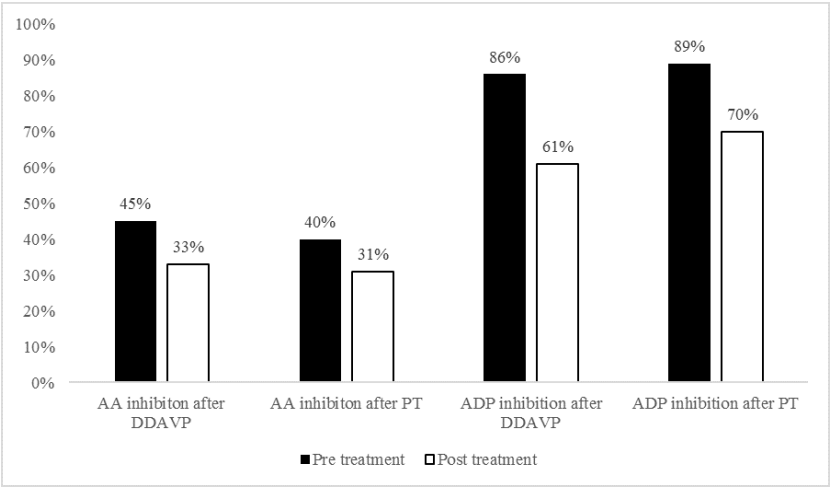
Introduction: Platelet dysfunction is an independent predictor of increased mortality in patients with severe traumatic brain injury (TBI). Platelet transfusions have been shown to be an effective treatment strategy to reverse platelet inhibition and reduce mortality, but may be associated with shortages, cost and transfusion related complications. Therefore, desmopressin (DDAVP) is an attractive alternative to enhance platelet aggregation. We hypothesized that DDAVP would correct platelet dysfunction similarly to platelet transfusions in patients with severe TBI.

Methods: This retrospective study evaluated all blunt trauma patients admitted to an urban, level one trauma center from July 2015 to October 2016 with severe TBI (Head AIS >/= 3) who presented with platelet dysfunction (defined as adenosine diphosphate (ADP) inhibition greater than 60% on thromboelastogram [TEG]) and subsequently received treatment. Per our institutional practice patients with severe TBI and platelet dysfunction are transfused a unit of apheresis platelets to reverse inhibition. If platelet inhibition persists the patient receives a second platelet transfusion. During a platelet shortage, we interchanged DDAVP for the initial treatment. Patients were classified as receiving DDAVP or platelet transfusion (PT) based on the initial treatment. Patients were excluded if hemostatic agents were given prior to first TEG or DDAVP was co-administered with the platelet transfusions.

Results: A total of 57 patients were included (DDAVP [n=23]; PT [n=34]). When comparing the DDAVP group to the PT group there was no difference in age (41 vs. 40, p=0.86), male gender (82% vs. 74%, p=0.44), but PT patients were more often Caucasian (94% vs. 65%, p=0.005). There was no difference in admission systolic blood pressure (138 vs. 142, p=0.68) or pulse (97 vs. 105, p=0.30). Patients who received DDAVP were more severely injured (ISS: 29 vs. 23, p=0.045) but there was no difference in Head AIS (4 vs. 4, p=0.16). Prior to treatment both groups had similar admission platelet counts (276 vs. 256, p=0.70) as well as arachidonic acid (AA) and ADP inhibition as measured by TEG, AA (45% vs. 40%, p=0.58) and ADP (86% vs. 89%, p=0.34). After treatment both the DDAVP and PT groups had similar correction of platelet inhibiton along the AA (p=0.80) and ADP (p=0.28) pathways (Figure 1).

Conclusion: In patients with severe TBI and platelet dysfunction, DDAVP is an alternative to platelet transfusions to correct platelet dysfunction.

Figure 1: Change in platelet inhibition along the AA (p=0.80) and ADP (p=0.28) pathways for DDAVP vs. platelet transfusion.



Session: Session XIX: Papers 45-47: Coagulation
Paper 45: 9:45-10:05 am

A Novel Platelet Function Assay for Trauma

Mitchell J. George MD, Charles E. Wade Ph.D., Charles S. Cox* Jr., MD, Brijesh S. Gill MD,
McGovern Medical School

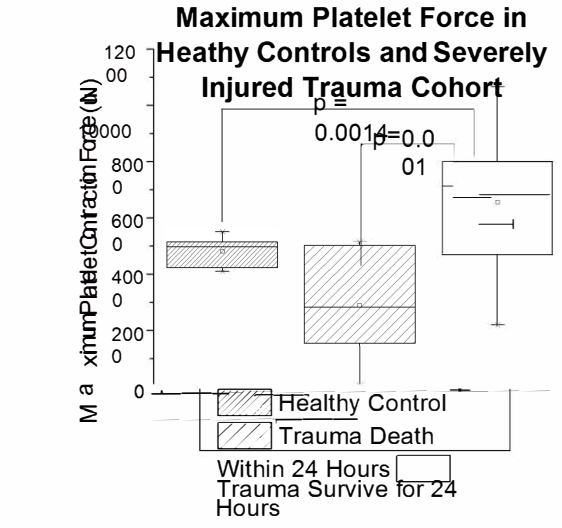
Invited Discussant: Carrie Sims, MD

Background: Platelet function tests like thromboelastography platelet mapping and impedance aggregometry have demonstrated significant reductions in platelet function in all trauma patients. However, these two tests correlate poorly with one another and require reagents like arachidonic acid or adenosine diphosphate for activation. In this study we introduce a platelet function test that measures platelet contraction forces directly, the platelet contraction assay (PCA), without pathway specific reagents. Platelet contraction is the final phase of platelet activation and requires energetic substrates to drive actin-myosin crosslinking. We hypothesize that this platelet function test will correlate with established coagulation tests like thromboelastography (TEG), demonstrate significant differences between healthy subjects and trauma patients, and identify critically ill trauma patients.

Methods: Initial blood samples from eighty Level 1 Trauma patients with median ISS of 13 (4, 17) were assayed in the PCA and compared to their initial TEG data using regression analysis. Blood from ten healthy subjects was assayed seperately to establish a reference range. Results from trauma patients surviving beyond 24 hours after admission were compared to healthy controls and trauma deaths within 24 hours after admission using analysis of variance (ANOVA) with Tukey post-hoc analysis. The primary PCA metric was maximum platelet contraction force (MF). The PCA measures platelet contraction forces in whole blood that clots between two plastic discs in a heated chamber.

Results: The PCA MF correlates with TEG MA with R^2=0.756 according to a power curve regression of all eighty trauma patients. Trauma patients that survived for 24 hours after arrival (N=74) demonstrated significantly elevated maximum platelet contraction forces compared to healthy controls (6,705±2370 versus 4,825±480 µNewtons, p=0.0014) and trauma patients that died within 24 hours (6,705±2370 versus 2,904±2122 µNewtons, p=0.001). Those that died within 24 hours demonstrated non-significant decreases compared to healthy controls (2,904±2122 versus 4,825±480 µNewtons, p=0.11). Of the six that died, four were from brain injury and two from blunt trauma.

Conclusions: The PCA is a platelet specific assay that correlates well with TEG MA and predicts early mortality in severely injured trauma patients. Unlike thromboelastography platelet mapping and impedance aggregometry, the PCA demonstrates increased platelet function in trauma patients unless they die within 24 hours. An explanation for this difference is that platelet contraction is reflective of platelet metabolics and thus a potential biomarker for survival after trauma.



Session: Session XIX: Papers 45-47: Coagulation
Paper 46: 10:05-10:25 am

TRANEXAMIC ACID CAUSES A ROBUST AND PROLONGED FIBRINOLYTIC SHUTDOWN

Julia R. Coleman MD,MPH, Ernest E. Moore* MD, Angela Sauaia MD,Ph.D., Jason M. Samuels MD, Geoffrey R. Nunns MD, Gregory R. Stettler MD, Joshua Ryon BA, Arsen Ghasabyan MPH, James Chandler Anirban Banerjee Ph.D., Christopher C. Silliman MD,Ph.D., Kenneth L. Jones Ph.D., University of Colorado Denver

Invited Discussant: Nicholas Namias, MD, MBA

Introduction: Tranexamic acid (TXA), an antifibrinolytic, has been used in military and civilian trauma, but its preemptive utility has been called into question over mixed evidence of survival benefit and increased thromboembolism. This study examines the changes in fibrinolysis over time after TXA administration in trauma patients. We hypothesize that TXA causes conversion to fibrinolytic shutdown which could have thromboembolic consequences.

Methods: The Trauma Activation Protocol study is a prospective study of all trauma activation patients admitted to a Level 1 Trauma Center. Whole blood samples were collected at scene or upon presentation and at 2, 4, 6, 12, 24 and 48 hours. Citrated rapid thrombelastography (TEG) was performed. LY30 (% lysis 30 minutes after maximum amplitude) was examined and lysis phenotypes were defined as fibrinolytic shutdown (LY30<0.9%), physiologic lysis (0.9%≥LY30<3.0%) and hyperfibrinolysis (LY30≥3.0%). LY30 was compared at each time point between patients who received TXA versus those who did not using a Mann-Whitney test, as well as through propensity matched analysis to control for covariates. The incidence of venous thrombo-embolic events (VTE) was examined by chi-square analysis.

Results: Overall, 274 patients were included. The median age was 31.4 years and 79% were male. 59% presented after blunt trauma and the median new injury severity score (NISS) was 33. 41 patients (15%) received TXA. Patients who received TXA had a higher level of tissue injury (NISS of 43 vs 29, p=0.01) and more severe shock (base deficit of -14.0 mEq/L vs -8.0 mEq/L, p<0.0001). TXA patients had more severe clot breakdown on admission compared to non-TXA patients (median LY30 8.2% vs 1.2%, p<0.0001). By two hours, the median LY30 of TXA patients decreased to 0.3% (vs 0.7% in non-TXA patients) and by hour 4, the median LY30 of TXA patients reflected complete fibrinolytic shutdown with an LY30 of 0.0% (vs non-TXA patients' LY30 of 0.6%, p=0.02). Remarkably, the complete inhibition of lysis among TXA patients persisted at 24 hours, with median LY30 of 0.0% in TXA patients compared to 0.6% in non-TXA patients (p=0.005). Even when controlling for baseline differences, degree of shock and tissue injury, LY30 was still significantly lower in the TXA group (p=0.05). Patients who received TXA had a trend towards increased rate of VTE (10% compared to 5% in non-TXA patients), although this did not reach statistical significance (p=0.27).

Conclusion: TXA causes a more robust and prolonged conversion to fibrinolytic shutdown in trauma patients compared to patients who do not receive TXA, a conversion which persists to at least 24 hours. Although TXA reverses the hyperfibrinolytic profile, it results in overcorrection with a transition to fibrinolysis shutdown within four hours of administration. This may put patients at a higher risk for VTE, which is strongly associated with fibrinolytic shutdown.

Session: Session XIX: Papers 45-47: Coagulation
Paper 47: 10:25-10:45 am

EARLY FIBRINOLYSIS SHUTDOWN IS ASSOCIATED WITH INCREASED NEUROSURGICAL INTERVENTIONS AFTER TRAUMATIC BRAIN INJURY: IS SHUTDOWN AN EARLY MARKER OF HYPOCOAGULABILITY RATHER THAN HYPOFIBRINOLYSIS?

Johana C. Gomez-Builes MD, Ori D. Rotstein MD, FRCP, Andrew Baker MD, Sergio A. Acuna MD,Ph.D., Andrea Petropolis MD, FRCP, Mostafa Alwash MD, Arshpreet Gulati MD, Ghassan Alkefeiri MD, Alan Rechamberg Ziroldo Estevao Pardi Sandro Rizoli* MD,Ph.D., FACS, FRCP St Michael's Hospital

Invited Discussant: Martin Schreiber, MD

Introduction: Following a traumatic brain injury (TBI), patients' outcome depends on the severity of the primary brain damage and the secondary brain insults, including intracranial hemorrhage progression (IHP). Coagulopathies, such as excessive fibrinolysis, have been associated with IHP and the need for neurosurgical intervention (NSX), but the association of hypofibrinolysis or fibrinolysis shutdown with IHP and NSX has not been studied.

Methods: A retrospective cohort of patients with moderate to severe TBI (AIS head≥ 2), admission ROTEM™, and serial imaging (CT head at admission and within 48 hours). Clinical, laboratory and CT findings were reviewed, including the type of intracranial hemorrhage (ICH), and number of ICH. IHP was defined as any new hemorrhage or worsening of admission-ICH. Patients were classified according to fibrinolysis phenotypes (physiologic, hyperfibrinolysis and shutdown). ROTEM™ ML<3.5% was used to define shutdown (as recently published by our group). Univariable and multivariable logistic regression evaluated the association between shutdown and progression, NSX, and mortality.

Results: 173 patients were included. 41.6% had IHP and 18% had a NSX. Predominant fibrinolysis phenotype was physiologic (71%), followed by shutdown (25.4%) and hyperfibrinolysis (3.4%). Shutdown patients had higher ISS, lower base excess and required more transfusions than the physiologic group. Progression was independently associated with fibrinogen level (OR 1.3, 95%CI:1.02-1.65, p= 0.03), INR (OR 0.5, 95% CI: 0.3-0.9, p= 0.04), and Glasgow Coma Scale motor response (GCSM, OR:1.38; 95% CI: 1.1-1.72, p= 0.003), but not with shutdown (OR 1.12; 95%CI: 0.4-2.5; p= 0.78), platelets, age, or acidosis. Shutdown (OR 3.1; 95%CI:1.8-8.2, p=0.02) and the number of ICH (OR 1.5, 95%CI: 1-2.4, p= 0.04) were independently associated with NSX. Platelets, fibrinogen level, INR, age, acidosis, GCSM, IHP were not associated with NSX. Age (OR1.4; 95%CI: 1.1-1.7, p=0.0008), GCSM (OR: 2.2; 95%CI: 1.5-3.2, p <0.0001), NSX (OR 5.6; 95%CI: 1.2-24.7, p=0.02), were independently associated with mortality. IHP (p=0.06), acidosis (p=0.06), and shutdown (p=0.9) were not associated with mortality.

Conclusions: This is the first study to explore the association between early fibrinolysis shutdown and progression of intracranial hemorrhage, and the need for neurosurgery. We found an independent association of shutdown with the need for NSX, which could be explained by a significant hemostatic activation (increased clot formation with fibrinogen consumption, and higher transfusions needs) rather than hypofibrinolysis. Fibrinolysis shutdown as an early marker of hypocoagulability could facilitate the recognition of patients at risk of neurosurgical interventions and thus, assist in the reduction of the secondary brain damage.

Session: Session XXII: Papers 48-56
Paper 48: 2:00-2:20 pm

A NOMOGRAM PREDICTING THE NEED FOR BLEEDING INTERVENTIONS AFTER HIGH-GRADE RENAL TRAUMA: RESULTS FROM THE AMERICAN ASSOCIATION FOR THE SURGERY OF TRAUMA (AAST) GENITOURINARY TRAUMA STUDY

Sorena Keihani MD, Douglas M. Rogers MD, Bryn E. Putbrese MD, Kaushik Mukherjee* MD, Sarah Majercik* MD, Christopher M. Dodgion* MD,MPH, Scott A. Zakaluzny* MD, Brian P. Smith* MD, Jurek F. Kocik* MD, Matthew M. Carrick* MD, Reza Askari* MD, Angela P. Presson Ph.D., James M. Hotaling MD, Raminder Nirula* MD,MPH, Jeremy B. Myers MD, University of Utah

Invited Discussant: Hunter Wessells, MD

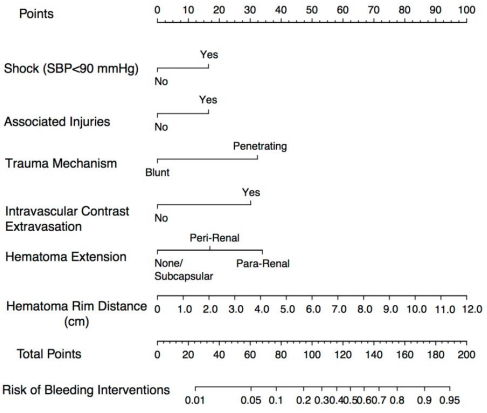
Introduction: The management of high-grade renal trauma (HGRT) and the indications for intervention remain poorly defined. The American Association for the Surgery of Trauma (AAST) renal grading is a broad categorization of injury severity and does not incorporate clinical and radiologic variables important in clinical decision-making especially around bleeding interventions. We aimed to use data from our multi-institutional study, incorporating both clinical and radiologic parameters, to develop a nomogram predicting risk of bleeding interventions after HGRT.

Methods: From 2014 to 2017, data on adult HGRT (AAST grades III-V) were collected from 14 participating Level-1 trauma centers. Patients with both clinical and radiology data were included. Data were gathered on demographics, injury characteristics, management, and outcomes. Clinical parameters, easily obtained and previously shown to be associated with bleeding interventions included: (1) trauma mechanism, (2) shock (systolic blood pressure <90 mmHg), (3) associated injury (i.e. any concomitant injury, including: solid organ, gastrointestinal, spinal cord, major vascular, and pelvic fracture), (4) admission lactate levels, and (5) admission hemoglobin level. Initial CT-scans were reviewed by two radiologists to extract renal injury specifics which included: (1) intravascular contrast extravasation (ICE), (2) hematoma rim distance (HRD, i.e. largest measure from the edge of the kidney to the hematoma), and (3) hematoma extension (none/subcapsular; peri-renal; para-renal [beyond the aorta on the left or IVC on the right or into the pelvis]), and (4) laceration location (lateral, medial, complex). Bleeding interventions included: nephrectomy (total or partial), renorrhaphy, renal packing, and renal-related angioembolization. We developed a prediction model by applying backward model selection to a logistic regression model that included the above mentioned clinical and radiologic variables. We developed a nomogram for the selected model and reported its accuracy as the area under the receiver operating characteristic curve (AUC) and its 95% confidence interval (CI).

Results: A total of 326 patients from the overall cohort of 431 met the inclusion criteria. Mechanism of injury was blunt in 81%, and 67% had one or more associated injuries. Mean age and injury severity score were 35.0±16.6 and 25.0±12.6. Injuries were reported as AAST grades III (60%), IV (33%), and V (7%). Overall, 47 (14%) underwent bleeding interventions including 19 renal angioembolization 16 nephrectomies, and 12 other procedures. ICE was found in 73 patients (23%). Hematoma extension was peri-renal in 160 (49%) and para-renal in 123 (38%); 43 (13%) had no hematoma or only subcapsular hematoma. Mean HRD in the horizontal plane was 2.1 cm (SD: 2.0). The nomogram for our bleeding intervention prediction model is presented in Figure-1. Of the clinical and radiologic variables entered in backward model selection, lactate, hemoglobin, and laceration location did not significantly improve the nomogram AUC, and were not included in the final model. Having a HRD of 12 cm was worth the most points (100), followed by para-renal hematoma extension (34 points), penetrating trauma mechanism (32 points), ICE (30 points), associated injuries (16 points), and shock (16 points). The AUC was 0.88 (95% CI: 0.83–0.92).

Conclusion: We developed a nomogram that integrates multiple clinical and radiologic factors immediately available upon assessment of the trauma victim and can provide predicted probability for risk of bleeding interventions after HGRT. While further studies are needed to validate our model, this nomogram may help in guiding appropriate interventions such as decreasing unnecessary interventions especially at lower volume trauma centers with limited experience with high-grade renal injuries.

Figure 1. Nomogram for our model predicting bleeding intervention



Session: Session XXII: Papers 48-56
Paper 49: 2:20-2:40 pm

PRESUMPTIVE ANTIBIOTICS FOR TUBE THORACOSTOMY FOR TRAUMATIC HEMOPNEUMOTHORAX

Susan P. Schultz MD, Chengcheng Hu Ph.D., Alan D. Cook* MD, Jeanette G. Ward MS-CR, Jeremy Juern MD, Geoffrey A. Funk MD, Ronald Gross* MD, David Turay MD, Steven R. Allen MD, Paola G. Pieri MD, Christopher P. Michetti MD, Frederick B. Rogers* MD, Shreya Jammula BS, Forrest O. Moore* MD, AAST ABX IN TUBE THORACOSTOMY STUDY GROUP AAST Multi-Institutional Trials Committee

Invited Discussant: Timothy Fabian, MD

Introduction: Despite more than forty years of investigation, presumptive antibiotic use for post-traumatic tube thoracostomy remains controversial. Researchers seek to balance prevention of infectious complications with antibiotic stewardship. This study investigated the benefit of presumptive antibiotic treatment for prevention of infectious complications following post-traumatic tube thoracostomy. The primary outcomes were pneumonia and empyema following chest tube insertion. Hospital and ICU lengths of stay (HLOS and ICULOS respectively), ventilator days, death and *C*. difficile colitis were secondary endpoints.

Methods: A prospective, observational, multi-center study included 1,887 subjects from 22 level I trauma centers. Nearest neighbor matching balanced covariate distributions in the treatment (ABX) and control (NoABX) groups. Variables used for matching included basic demographics, trauma center information, mechanism of injury, severity of injury, and details of chest tube placement.

Results: There were 272 patients in each group. No significant differences among matching covariates distinguished either group. No significant differences were found in primary outcomes between the ABX and NoABX groups. Pneumonia was diagnosed in 15.4% and 9.9% of the ABX and NoABX group, respectively, p=0.07. Similarly, 2.2% of the ABX group and 1.5% of the NoABX patients developed empyema, p=0.75. ICULOS was one day longer in the ABX group, p=0.02.

Binary Outcome	No ABX	ABX	Odds Ratio (OR) (95% CI)
Empyema	4 (1.5%)	6 (2.2%)	1.5 (0.42, 5.32)
Pneumonia	27 (9.9%)	42 (15.4%)	1.68 (0.99, 2.85)
Death	29 (10.7%)	24 (8.8%)	0.82 (0.47, 1.43)
Clostridium Difficile Colitis	3 (1.1%)	2 (0.7%)	0.67 (0.11, 3.99)
Count Outcome			**Rate Ratio (RR) (95% CI)**
ICU LOS*	2 (0, 6)	3 (0, 9)	1.27 (0.97, 1.68)
Hospital LOS	7 (4, 14)	8 (4, 16)	1.11 (0.96, 1.28)
Ventilation Days	0 (0, 3)	1 (0, 5)	1.36 (0.92, 2.01)

*$p<0.05$

Conclusion: This study found no evidence to support the use of presumptive antibiotics for post-traumatic tube thoracostomy in the absence of other indications.

Session: Session XXII: Papers 48-56
Paper 50: 2:40-3:00 pm

VASOPRESSOR USE IN SPINAL CORD INJURY INCREASES MORTALITY AND COMPLICATIONS WITHOUT IMPROVING SHORT TERM NEUROLOGIC FUNCTION

Caitlin A. Fitzgerald MD, Faiz U. Ahmad MD, Peter M. Rhee* MD, Bryan C. Morse* MD, Mark L. Shapiro* MD, Jonathan Nguyen DO, Sebastian D. Perez MSPH, Christian M. Mustroph MD, Griffin R. Baum MD, Rondi B. Gelbard MD, Emory University

Invited Discussant: David Zonies, MD, MPH

Introduction: An increase in spinal cord perfusion pressure is thought to improve neurologic outcomes after spinal cord injury (SCI) but this has yet to be shown in trauma patients. According to guidelines, vasopressors should be used to achieve a goal mean arterial pressure (MAP) to optimize spinal cord blood flow. However, the outcomes and complications associated with routine vasopressor use among SCI patients are not well established. The purpose of this study was to determine the outcomes associated with vasopressor use among SCI patients.

Methods: This was a retrospective review of all adult patients presenting to our Level 1 Trauma Center with acute traumatic SCI between September 2010 and September 2017. Patients were identified from the Trauma Registry using the International Classification of Diseases (ICD-9) codes for spinal cord injury. Patients were grouped according to whether they received vasopressors for MAP goals or not. Outcome measures included complications, hospital and Intensive Care Unit (ICU) length of stay (LOS), and change in American Spinal Injury Association (ASIA) impairment scale from admission to discharge.

Results: A total of 535 patients with SCI were identified. Of these, 113 (21.1%) had normal neurologic function on admission and were excluded from further analysis. A total of 55.4% (234/422) received vasopressors to achieve MAP goals >85 mmHg for an average of 4.6 days. Whether patients received MAP goals or not was based on surgeon's preference. There was no difference between the vasopressor and no vasopressor groups in terms of demographics. ASIA Grades at admission ranged from 168 (39.8%) ASIA A, 40 (9.5%) ASIA B, 84 (20%) ASIA C, and 116 (27.5%) ASIA D. There was no difference in short term neurologic improvement in ASIA A-D patients with the use of vasopressors. Overall mortality was higher among patients receiving vasopressors (25/234, 10.7% vs 2/174, 1.1%, p=0.001). Even after controlling for ISS and ASIA scores, vasopressors were independently associated with a significant increase in mortality (OR= 8.87, p=.004). Hospital and ICU LOS were also significantly longer in the vasopressor group (28 ±35 vs. 19.1±29 days, p=0.007, and 18±21.2 vs. 7.8 ± 8.9 days, p<0.001), as were cardiogenic complications such as myocardial infarction, acute kidney injury, sepsis, pneumonia and urinary tract infections.

	Vasopressor (n=234)	No Vasopressor (n=174)	p-value
ICU LOS	18.0 ± 21.2	7.8 ± 8.9	**<0.001***
Hospital LOS	28.0 ± 35.0	19.1 ± 29.2	**0.007***
Mean ASIA at Admission	2.1 ± 1.2	2.8 ± 1.3	**<0.001***
Mean Change in ASIA			
A	0.20 ± 0.63	0.16 ± 0.46	0.7
B	0.39 ± 0.69	0.33 ± 0.89	0.9
C	0.32 ± 0.47	0.51 ± 0.61	0.09
D	0.10 ± 0.48	0.22 ± 0.45	0.2
AKI	20 (8.5%)	3 (1.7%)	**0.003***
Sepsis	26 (11.1%)	2 (1.1%)	**<0.001***
Pneumonia	81 (34.6%)	25 (14.4%)	**<0.001***
UTI	31 (13.2%)	37 (21.3%)	**0.03***
Cardiac Arrest	28 (12.0%)	4 (2.3%)	**<0.001***
Mortality	25 (10.7%)	2 (1.1%)	**0.001***

AKI: acute kidney injury; UTI: urinary tract infection.
Table 1. Comparison of outcomes between SCI patients who received vasopressors and those who did not.

Conclusion: Although vasopressors may be of benefit in patients with SCI, our data shows an association with increased morbidity and mortality without improving short term neurologic recovery. Prospective studies are required to determine the potential long-term benefits, risks and costs of vasopressor use for achieving MAP goals in patients with SCI.

Session: Session XXII: Papers 48-56
Paper 51: 3:00-3:20 pm

PREHOSPITAL END TIDAL CO2: A SUPERIOR MARKER FOR MORTALITY RISK IN THE ACUTELY INJURED PATIENT

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Invited Discussant: Saman Arbabi, MD, MPH

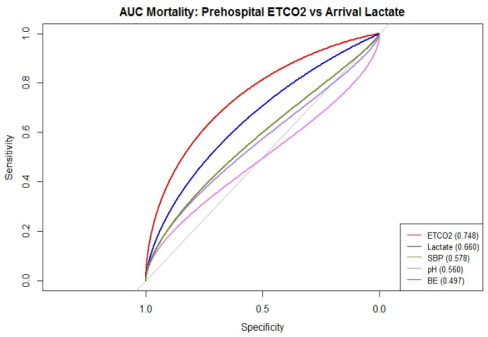
Introduction: Emergency medical personnel must expeditiously triage acutely injured patients to the appropriate medical facility. There continues to be a need for efficient and objective variables to facilitate this process and provide information to the receiving trauma center. Currently, multiple variables are used to prognosticate injury severity and risk of mortality including vital signs, mental status, lactate and base excess. We investigated the prehospital use of end tidal carbon dioxide (EtCO2) as a non-invasive physiologic measure that can be obtained in the acutely injured patient.

Methods: We performed a retrospective analysis of 557 acutely injured patients over two years (January 1, 2014- December 31, 2015) at a level I trauma center. All patients arriving as trauma activations with EtCO2 measurements were included in analysis. EtCO2 measurements were categorized as "low", "normal", and "high" based on standard reference levels. Mortality was the primary outcome. Secondary receiver operator curves (ROC) for base excess, venous lactate, blood pressure, and venous pH were also compared. We hypothesized EtCO2 levels would be able to predict mortality.

Results: EtCO2 levels conferred a mortality rate of 38%, 17.3%, and 2.9% for "low", "normal" and "high" respectively ($p<0.001$). Furthermore, ROC analysis produced an area-under-the-curve (AUC) predictive value for EtCO2 (0.748) which was superior to lactate (0.660), SBP(0.578), pH(0.560), and base excess(0.497).

Table 1. Mortality by End-Tidal CO2 Level (p-value <0.001)

EtCO2	Mortality (%)
Low	38.0
Normal	17.3
High	2.9



Conclusion: EtCO2 is a more sensitive and specific predictor of mortality in the acutely injured patient compared to venous lactate, base deficit, blood pressure, or venous pH. Additional studies are needed to determine if EtCO2 can be used as an effective prehospital adjunct to prevent mortality in acutely injured patients.

Session: Session XXII: Papers 48-56
Paper 52: 3:20-3:40 pm

PRE-INJURY PALLIATIVE PERFORMANCE SCALE (PPS) PREDICTS FUNCTIONAL OUTCOMES AT 6 MONTHS IN OLDER TRAUMA PATIENTS

Franchesca Hwang MD, Sri Ram Pentakota MD,MPH,Ph.D., Christopher McGreevy MD, Patricia Walling RN, MS, Dorsa Seimaa MPH,RN, Nina E. Glass MD, David H. Livingston* MD, Anne C. Mosenthal* MD, New Jersey Medical School

Invited Discussant: Karen Brasel, MD, MPH

Introduction: Older trauma patients have increased risk of adverse in-hospital outcomes than their younger counterparts. Previously, we demonstrated that low Palliative Performance Scale (PPS) independently predicted poor discharge outcomes. Yet, the ability to predict long-term outcomes beyond discharge is unknown. We hypothesized that pre-injury PPS would predict long-term outcomes in older trauma patients.

Methods: We conducted a prospective observational study of trauma patients aged ≥ 55 admitted to a level I trauma center (7/2016-10/2017). Pre-injury PPS, which takes 1-2 minutes to complete, was assessed at admission; low PPS was defined as ≤ 70. Primary outcomes were in-hospital mortality and Extended Glasgow Outcome Scale (GOSE) at discharge and 6 months. Secondary outcomes were patient-reported outcome measures at 6 months: EuroQol (EQ)-5D and 36-Item Short Form Survey (SF-36). Poor functional outcome was defined as GOSE ≤ 4. Multivariable logistic regression was performed for each primary outcome, adjusting for PPS, age, race, gender, and injury severity.

Results: We collected 376 patients' in-hospital data. The mean age was 70; the mean ISS was 14.8; and 30% had low PPS. Six percent (n=24) died in hospital (GOSE 1), and half of survivors (n=190) had severe disability (GOSE 3/4) at discharge. No vegetative state (GOSE 2) was observed. Low PPS was associated with in-hospital mortality (aOR 3.0, 95% CI 1.1-8.3) and poor functional outcomes at discharge among survivors (aOR 5.9, 95% CI 3.1-11.0). Severe TBI and ISS also predicted in-hospital mortality. Older age, higher ISS, and lower extremity fractures predicted poor functional outcomes at discharge. Six-month data were available for 113 (87%) of 130 patients who were approached for follow-up. Functional outcomes improved in 62% at 6 months (**Table**). However, 63% had moderate to extreme pain, and 43% felt moderately to extremely anxious/depressed. Low-PPS patients were less likely to improve GOSE than high-PPS patients (40% vs 70%). Low PPS independently predicted poor functional outcomes at 6 months (aOR 5.7, 95% CI 1.5-21.5) while age, ISS, and lower extremity fractures did not. A higher proportion of low-PPS patients had problems with EQ-5D mobility (92% vs 51%, p=0.0002) and usual activities (77% vs 44%, p=0.003); they also scored lower on the EQ-5D Visual Analogue Scale (59 vs 68, p=0.04) at 6 months. Similarly, the low-PPS group scored lower than the high-PPS group in SF-36 physical functioning (27 vs 54, p=0.0004) and general health domains (37 vs 53, p=0.01).

Conclusion: Pre-injury PPS predicts in-hospital mortality and poor functional outcomes at discharge and 6 months in older trauma patients. Patients with low PPS were less likely to improve their functional outcomes after discharge; interestingly, majority of survivors improved their function at 6 months, further emphasizing the importance of long-term follow-up in understanding their true outcomes. Pre-injury PPS is a quick, practical tool that can be utilized on admission for early prognostication of both short- and long-term outcomes.

Table: Change of GOSE over 6-month follow-up, stratified by pre-injury PPS (low: ≤ 70)

6-month Outcomes	Total (n=113)		Low PPS (n=30)		High PPS (n=83)		p-value
Died	7	*6%*	4	*13%*	3	*4%*	0.014
Worsened	13	*12%*	5	*17%*	8	*10%*	
No change	23	*20%*	9	*30%*	14	*17%*	
Improved	70	*62%*	12	*40%*	58	*70%*	

Session: Session XXII: Papers 48-56
Paper 53: 3:40-4:00 pm

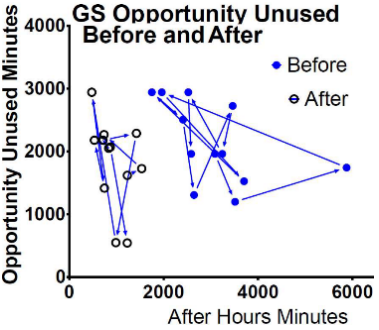
USING PERFORMANCE FRONTIERS TO DIFFERENTIATE ELECTIVE AND CAPACITY-BASED SURGICAL SERVICES

Stephen E. Ranney MD, Loic J. Fabricant MD, Max W. Breidenstein BS, Kevin W. Sexton MD, Ajai K. Malhotra* MD, Mitchell H. Tsai MD, University of Vermont

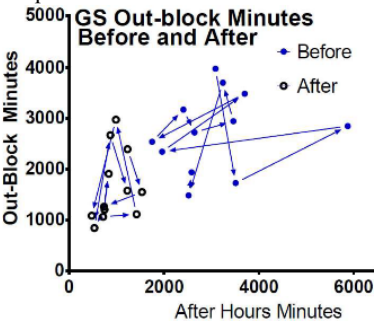
Invited Discussant: Kimberly Davis, MD, MBA

Introduction: In the past, our institution demonstrated how an Acute Care Surgery service (ACS) can improve the clinical productivity of surgical departments (AAST 2016, 2017); however, the application of current productivity models is limited and varied. At our institution, creating an ACS led to increased OR workload and a concomitant decrease in clinical productivity. Current productivity models incorporating over-utilized time may not apply to ACS systems because ACS is a capacity-based service and requires a 24-hour block allocation which falsely decreases productivity. Thus, a new technique to optimize multiple objectives is needed to determine the true utility of implementing ACS. Performance frontiers provide a mathematical and graphical system for evaluating a set of actions to determine optimal efficiency—a state where allocation of resources is optimal and where it is impossible to reallocate any resources without making any objective worse. We hypothesized that ACS and elective general surgery (GS) would differentiate themselves along separate pathways on superimposed performance fronts, and that the implementation of an ACS would help GS reach optimal efficiency.

Methods: We extracted the time for in-block, out-of-block, after-hours, and opportunity-unused for GS and ACS for 12 months prior to and after implementing ACS. Monthly data was plotted along performance fronts and was viewed graphically using GraphPad Prism®. For each month, over-utilized time was plotted on the x-axis and in-block and out-of-block times were plotted on the y-axis.



Results: The performance frontiers demonstrated obvious differences in OR utilization between ACS and GS. Statistically, ACS had a significant increase in opportunity unused minutes. The GS showed a significant decrease in after-hours, out of block, and opportunity unused time. Although not statistically significant, an upward trend of in-block time was observed.



Conclusion: The application of performance fronts to productivity and OR utilization metrics hints at the limitations of the current models. The graphs demonstrate falsely elevated opportunity unused for ACS while showing an increase in GS OR efficiency. This suggests that hospital administrators, OR managers, and physician leaders need different frameworks to understand capacity-based services and to identify limitations of operational efficiency as well as to describe the full value of an ACS model to a whole surgical department, not an individual service. Performance fronts will allow for OR managers to track efficiency of multiple services while making such changes.

Session: Session XXII: Papers 48-56
Paper 54: 4:00-4:20 pm

MINIMALLY INVASIVE PREPERITONEAL BALLOON TAMPONADE AND ABDOMINAL AORTIC JUNCTIONAL TOURNIQUET VERSUS OPEN PACKING FOR PELVIC FRACTURE-ASSOCIATED HEMORRHAGE: NOT ALL EXTRINSIC COMPRESSION IS EQUAL

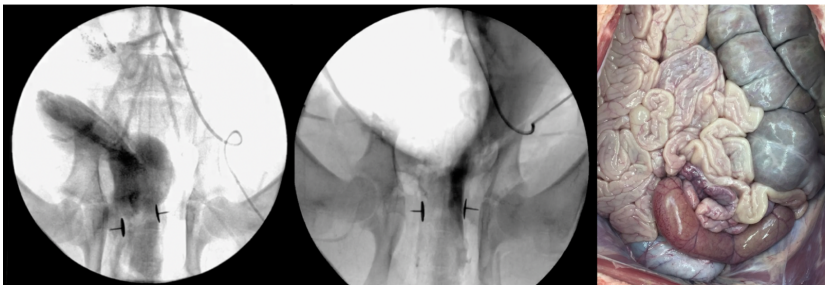
Woo S. Do MD, Dominic M. Forte MD, Rowan R. Sheldon MD, Jessica B. Weiss MD, Morgan R. Barron MD, Kyle K. Sokol MD, George E. Black MD, Matthew J. Eckert MD, Matthew J. Martin* MD, Madigan Army Medical Center

Invited Discussant: Clay Cothren, MD

Introduction: Minimally invasive preperitoneal balloon tamponade (PPB) and abdominal aortic junctional tourniquets (AAJT) have been proposed as alternatives to open preperitoneal packing (OP) for the management of pelvic fracture associated hemorrhage. We compared the effectiveness of PPB (SpaceMaker Pro ^{TM}) and AAJT against the standard of care (OP) in an animal model of open-book pelvic fracture.

Methods: 28 swine underwent creation of a combined open-book pelvic fracture and major iliac vascular injuries. Animals were randomized to no intervention (n=7), OP (n=8), PPB (n=7), or AAJT (n=6) at a mean arterial pressure <40 mmHg following initiation of uncontrolled hemorrhage. Hemodynamics, laboratory values, survival time (up to 60 min), preperitoneal pressure, and blood loss were compared between groups.

Results: Prior to injury, no significant difference was measured between groups for variables including weight, hemodynamics, lactate, and hematocrit (all p=NS). The injury was uniformly lethal without intervention, with survival time (mean) of 5 min, peak preperitoneal pressure of 14 mmHg, blood loss of 1010 cc, and peak lactate of 2.6 mmol/L. Mean survival time was 44 min with OP, and was significantly longer at 60 min with PPB and AAJT ($p<0.01$). Peak preperitoneal pressure was 21 mmHg with OP, 24 with PPB, and 23 with AAJT (p=NS). Blood loss was 850 cc with OP, 780 cc with PPB, and 610 cc with AAJT (p=NS). Peak lactate was 3.0 mmol/L with OP, 3.8 mmol/L with PPB, and 6.3 mmol/L with AAJT ($p<0.01$). Necropsy revealed bowel/bladder injury in 50% of AAJT subjects compared to 0% in all other arms ($p<0.01$). The following figure depicts free pelvic hemorrhage on angiography (left); tamponade with PPB inflation (middle); and bowel injury with AAJT (right).



Conclusion: PPB is a safe and more effective alternative to OP for the management of lethal pelvic fracture associated hemorrhage, and has several significant advantages including the ease of bedside placement. The AAJT offers a similar survival benefit to PPB but has concerning rates of compressive abdominal organ injury.

Session: Session XXII: Papers 48-56
Paper 55: 4:20-4:40 pm

OUTCOMES FOR POPLITEAL ARTERY INJURY REPAIR AFTER DISCHARGE: A LARGE-SCALE POPULATION-BASED ANALYSIS

William J. Butler MD, Richard Y. Calvo Ph.D., Michael J. Sise* MD, Vishal Bansal* MD, C. Beth Sise MSN, Jason M. Bowie MD, Lyndsey E. Wessels MD, Scripps Mercy Hospital Trauma Service

Invited Discussant: David Feliciano, MD

Introduction: Data suggest that the short-term results after endovascular repair (EvR) versus open repair (OpR) for popliteal artery injury are similar. However, studies on the outcomes after discharge are limited. We evaluated popliteal artery injury repair in a large population-based dataset. We hypothesized that post-discharge outcomes for OpR are superior to EvR.

Methods: Patients with popliteal artery injury were identified in the California Office of Statewide Health Planning and Development 2007-2014 patient discharge database. Popliteal arterial and other lower-extremity skeletal, vascular, and nerve injuries were identified using ICD-9-CM diagnosis codes. Procedure codes were evaluated to identify OpR, EvR, fasciotomy, and lower-extremity amputation. Primary outcomes were in-hospital mortality or amputation during index admission. The association between repair method and each outcome was evaluated with logistic regression. Post-discharge amputation and death were evaluated using survival analysis.

Results: We identified 769 patients with popliteal artery injury. Most were male (85%), mean age was 38.1 (SD: 16.5) years, and median ISS was 13 (IQR: 9 – 21). OpR occurred in 456 (59.3%) patients, EvR in 37 (4.3%), combined EvR and OpR in 18 (2.3%), and non-operative management in 258 (33.6%). Although fasciotomy was performed more frequently in OpR compared to EvR (40.8% vs 18.9%, $p< 0.01$), amputation during the index admission was not significantly different (10.5% vs 2.7%, $p = 0.13$). Arterial embolism or thrombosis during the index admission was more likely after EvR or combined EvR and OpR compared with OpR (24.3%, 55.6% and 16.7% respectively, $p <0.001$). Patients who required both EvR and OpR were 5.18 times (95%CI: 1.39-19.34) more likely to undergo amputation after discharge and 4.44 times (95%CI: 1.27–15.57) more likely to die after discharge compared to patients who only had OpR (median 98.5 days from discharge).

Conclusion: In a large cohort with popliteal artery injury, OpR was associated with lower rates of arterial thrombus or embolism and both amputation and mortality after discharge. Our results suggest that OpR is superior and that EvR needs to be carefully evaluated to determine its appropriate use in managing popliteal artery injuries.

PAPER 56 - WITHDRAWN

Session: Session XXIII: Papers 58-65
Paper 57: 2:00-2:20 pm

APPLICATION OF EMR-DERIVED ANALYTICS IN CRITICAL CARE: ROTHMAN INDEX PREDICTS MORTALITY AND READMISSIONS IN SURGICAL ICU PATIENTS

Abdul Q. Alarhayem MD, Mark T. Muir* MD, Donald Jenkins* MD, Brian J. Eastridge* MD, Maulik Purohit MD,MPH, Basil A. Pruitt* Jr., MD, Ramon F. Cestero* MD,
University of Texas Health Science Center at San Antonio

Invited Discussant: Sonlee West, MD

Introduction: The Rothman Index (RI) is an objective measurement of a patient's overall condition, automatically and continuously calculated from clinical data in the electronic medical record (EMR). A maximum score of 100 reflects no additional mortality risk, and a decreasing score signifies a deteriorating clinical status. Although studies in medical patients suggest that RI scores may predict mortality and readmission rates, RI has not been extensively evaluated in the surgical population. This study assessed the validity of RI in predicting surgical ICU (SICU) readmission rates and mortality. We hypothesized that lower pre-transfer RI scores are associated with higher mortality and SICU readmission rates.

Methods: We conducted a single-center retrospective analysis over a two-year period at a Level I trauma center which included surgical patients who were transferred from the SICU to the surgical floor. Data included demographics, length of stay (LOS), mortality, and RI at multiple pre-transfer time points (72, 48, and 24 hours before transfer) as well as 24 and 48 hours post-transfer. Patients readmitted to the SICU within 48 hours of transfer were compared with patients who did not require readmission within 48 hours (control).

Results: A total of 1,445 SICU patients were transferred to the surgical floor; 79 patients (5.5%) were readmitted within 48 hours of transfer. Demographics were similar in both groups. Mean age was 52, and 67% were male. Compared to controls, patients readmitted to the SICU within 48 hours experienced higher LOS (29 vs 11 days, $p<.05$) and higher mortality (2.5% vs 0.6%, $p<.05$). Patients requiring readmission also had a lower RI at 72, 48, and 24 hours before transfer as well as at 24 and 48 hours after transfer ($p<.05$ for all). Additionally, patients requiring readmission had less improvement in RI scores during the immediate 24 hours after transfer (1 vs 17, $p<.05$). In trauma patients ($n = 719$), lower RI scores at 24 hours prior to transfer correlated with an increase in ISS and mortality ($p<0.05$). Patients transferred with RI scores > 83 did not require SICU readmission within 48 hours. The AUC value of RI for predicting mortality, calculated from the receiver operator characteristic (ROC) curve, was 0.865 with standard errors of 0.05.

Conclusion: SICU patients requiring readmission within 48 hours of transfer to a surgical floor have a significantly higher mortality and longer LOS compared to those who do not. Patients requiring readmission also have significantly lower pre- and post-transfer RI scores compared to those who do not. Lower RI values at 24 hours before transfer are predictive of higher readmission rates and increased mortality risk, and patients with pre-transfer RI scores >83 are unlikely to require early SICU readmission. As an EMR-derived composite clinical measurement, RI scores may be used as a tool for evaluating patients prior to SICU downgrade, and can assist in identifying patients at higher risk for mortality and ICU readmission. Prospective studies are warranted to further validate use of this technology.

Session: Session XXIII: Papers 58-65
Paper 58: 2:20-2:40 pm

Predisposed to Failure? The Challenge of Rescue in the Medical Intensive Care Unit

Alexandra Briggs MD, Robert Handzel MD, Matt Kutcher MD, Andrew B. Peitzman* MD, Raquel Forsythe* MD, University of Pittsburgh

Invited Discussant: Lena Napolitano, MD, MPH

Introduction: Patients in the Medical Intensive Care Unit (MICU) develop acute surgical processes that require operative intervention. While the increased mortality in emergency general surgery (EGS) patients is established, there are limited data addressing outcomes in the MICU population. The aim of our study was to characterize the breadth of surgical consults from the MICU and assess the mortality of patients requiring EGS.

Methods: All patients with an EGS consult originating from the MICU in a large urban academic medical center between January 2010 and 2016 were identified from a prospective, electronic medical record-based acute care surgery registry. Charts were reviewed to determine the reason for consult and the surgical procedures performed. Descriptive statistics were used to characterize patient demographics and outcomes for both the entire cohort and patients who underwent abdominal operations.

Results: Over this six year period, 911 MICU patients were seen by our service, 578 (63.4%) for an abdominal consult question, 333 (36.6%) for a non-abdominal question. A total of 411 patients (45.1%) underwent an operative procedure (186 abdominal, 225 non-abdominal). Patients undergoing abdominal operations had a mean age of 59.6, 53.2% male. The postoperative unadjusted mortality rate in patients undergoing abdominal operations was 37% (69/186), significantly higher than the unadjusted mortality rate of 16.4% (1833/11192) for all patients admitted to the MICU over the same time period. Damage control procedures were performed in 65 patients (34.9%), with 46.2% mortality in this group. The most common procedures were bowel resections, which had a postoperative mortality of 44.4% (32/72) and procedures for severe clostridium difficile infection, mortality rate of 34.8% (8/23). The highest mortality procedures were those relating to feeding tube complications and decompressive laparotomies, though these were performed in a small number of patients. Twenty-seven patients met our definition of surgical rescue, requiring operative intervention for complications of prior procedures. The majority of surgical rescue patients (19/27, 70.4%) had undergone procedures at an outside facility. Mortality in the surgical rescue population was 48%. Twenty-six patients had abdominal pathology amenable to surgical intervention but did not undergo surgery, with a mortality of 100%.

	All patients	Abdominal Operations
	n = 911	n = 186
Age	57.7 +/- 16.5	59.6 +/- 15.2
Male Gender	478 (52.5%)	99 (53.2%)
Hospital Length of Stay (Days)	24.9	25.7
ICU Length of Stay (Days)	16.8	16.2
Ventilator Days	17.7	13.3
Admission via the ED	382 (41.9%)	64 (34.4%)
Discharge to Home	228 (25.0%)	34 (18.3%)
Mortality		
Admission	242 (26.6%)	69 (37.1%)
30 day	224 (24.6%)	61 (32.8%)
1 year	408 (44.8%)	93 (50%)

Conclusions: Twenty percent of EGS consults from the MICU had an abdominal process requiring an operative intervention. This patient population has significant comorbidities with a low tolerance for intraabdominal processes, resulting in high mortality. Surgical rescue is particularly challenging for patients with prior procedural complications. While the MICU population as a whole has a high baseline mortality, patients requiring abdominal surgical intervention are at an even higher risk.

	Cases (n)	Postoperative Mortality n , (%)	Damage Control Procedures n , (%)
Appendectomy	4	0 (0%)	0 (0%)
Bowel Resection	72	32 (44.4%)	47 (65.3%)
Cholecystectomy	9	1 (11.1%)	0 (0%)
Clostridium Difficile Procedure	23	8 (34.8%)	2 (8.7%)
Decompressive Laparotomy	4	3 (75%)	4 (100%)
Feeding Tube Complications	5	4 (80%)	1 (20%)
Ulcer Disease	11	2 (18.2%)	2 (18.2%)
Intraoperative Determination of Futility	4	4 (100%)	0 (0%)
Negative Procedure	21	5 (23.8%)	2 (9.5%)
Other	33	10 (30.3%)	7 (21.2%)
Total	186	69 (37.1%)	65 (34.9%)

Session: Session XXIII: Papers 58-65
Paper 59: 2:40-3:00 pm

ULTRASONGRAPHIC IVC DIAMETER RESPONSE AFTER ONE HOUR OF TRAUMA RESUSCITATION PREDICTS 24 HOUR FLUID REQUIREMENT

Jay Doucet* MD, Paula Ferrada* MD, Ram Nirula* MD,MPH, Sarah Murthi* MD, Jinfeng Han BSN, Andrew Singleton MD, Katie Birkas M.Sc., Daniel Haase MD, Sara Edwards MD, Giovanna Casola MD, Raul Coimbra* MD,Ph.D., AAST
Multi-Institutional Trials Committee

Invited Discussant: Grace Rozycki, MD, MBA

Introduction: Identification of occult hypovolemia in trauma patients at admission can be difficult without additional laboratory evaluation or advanced imaging. We hypothesized that in acute trauma patients, the response of ultrasound-measured inferior vena cava diameter (IVCd) or mean internal jugular diameter (IJd) in repeated eFAST examinations (USA-IVC) during standard-of-care intravenous fluid resuscitation would predict 24 hour resuscitation intravenous fluid requirements.

Methods: An interim analysis of the NTI / AAST-MITC group prospective, multi-institutional IVC-FAST cohort trial was conducted at 4 Level I Trauma Centers. Major trauma patients were screened in the supine position for an IVCd of 12 mm or less on the initial FAST examination for enrollment. A second IVCd was obtained 40-60 minutes later, after the patient received standard-of-care fluid resuscitation. Patients whose second measurement IVCd remained less than 10mm were deemed Non-Responders (NON-RESP), those at or greater than 10mm were Responders (RESP). Prehospital fluid, initial resuscitation fluid and 24 hour fluid requirements were recorded. Demographics, ISS, arterial blood gasses, ICU admission, length-of-stay, interventions and complications were recorded. Means were compared by ANOVA and categorical variables were compared via Chi-square. Receiver-operator characteristic (ROC) curves were used to compare the FAST-IVC test to Base Excess (BE), ISS and other fluid volume predictors.

Results: There were 4798 patients screened by FAST-IVC, 378 were identified with admission IVCd < 12mm, 127 were enrolled and had useable imagery. There were 80 RESP and 47 NON-RESP. Table 1 shows the univariate analysis. NON-RESP needed significantly more fluid at 24 hours. ROC analysis indicates IVCd (AUC= 0.63, C.I.: 0.51-0.74, p=0.037) but not IJd (AUC= 0.42, C.I.: 0.24-0.60, p=N.S.) was comparable to ISS (AUC=0.75, C.I.:0.60-0.90, p=0.002) in predicting 24 hour fluid requirement.

Table 1: Results	**RESP (n=80)**	**NON-RESP (n=47)**	***p* value**
Age (yrs)	51.9 ± 24	57.9 ± 22	N.S.
Gender (% Male)	58% M	69% M	N.S.
ISS	8.4 ± 7.4	11.9 ± 8.6	p=0.045
Base Excess	-0.09 ± 3.2	-1.12 ± 5.1	N.S.
Admission Sys BP (mmHg)	136 ± 18	133 ± 25	N.S.
Prehospital IV Fluids (ml)	95 ± 227	80 ± 242	N.S.
Initial Resus Fluids (ml)	433 ± 519	410 ± 466	N.S.
Post-resus min IVCd (mm)	12.45 ± 5.7	6.19 ± 2.9	p< 0.0001
Post-resus mean min IJd (mm)	7.6 ± 3.9	5.4 ± 3.5	N.S.
24-hour Fluids (ml)	1640 ± 922	2604 ± 1187	p= 0.046
Mortality	1/80	1/47	N.S.

Conclusion: eFAST ultrasound IVC diameter, but not IJ diameter response to initial trauma resuscitation is useful in predicting 24 hour fluid resuscitation requirements.

Session: Session XXIII: Papers 58-65
Paper 60: 3:00-3:20 pm

VENTILATOR ASSOCIATED EVENT, NOT VENTILATOR ASSOCIATED PNEUMONIA, IS A TRUE QUALITY INDICATOR

Ashley D. Meagher MD,MPH, Margaret Lind MS, Lara Senekjian MD, MS, Chinenye Iwuchukwu MD,MPH, John B. Lynch MD,MPH, Joseph Cuschieri* MD, Bryce R. Robinsom* MD, MS University of Washington

Invited Discussant: Martin Croce, MD

Introduction: Ventilator associated pneumonia (VAP) is an unreliable and inconsistent quality indicator for trauma patients that require mechanical ventilation (MV) for greater than 48 hours. In an effort to reduce variability and subjectivity of ventilator-associated conditions, the Centers for Disease Control and National Health Safety Network defined criteria for ventilator-associated events (VAE), which include the qualitative components of VAP. The aim of this study is to identify the incidence of VAE in our trauma population and the impact on outcome, compared to the traditional definition of VAP.

Methods: We retrospectively reviewed all trauma patients admitted to our trauma center between 2011 and 2017 that required at least 4 days of MV, excluding those with AIS head >4. This data was matched to our institutional physician adjudicated and culture confirmed VAP and VAE database. The primary outcome was in-hospital mortality, with discharge home and hospital length of stay as the secondary outcomes. We used Cox proportional hazard models with time-varying exposure to estimate the associations between VAE and VAP and in-hospital mortality, duration of MV, and discharge home.

Results: 1,753 trauma patients met criteria; 12% (n=221) of these developed a VAE, 7% (n=117) developed a VAP, and 4% (n=73) had both. Baseline characteristics were not different between those with VAE, VAP or both. After adjusted analyses, patients with VAE had statistically significantly higher likelihood of death, longer MV, and were less likely to discharge home (Table 1). Patients with VAP had no statistically significant likelihood of death, but were more likely to require MV, and less likely to discharge home. The probability of developing a VAP was 6%, developing a VAE was 15%, and developing both VAE and VAP was 7%.

Conclusions: Critically injured trauma patients develop VAE at double the rate of VAP. Compared to those with VAP alone, those who develop VAE are more likely to die and utilize more MV. VAE is a quality measure with objective criteria that should be utilized in trauma critical care units. Efforts should be made to identify risk factors for VAE as these patients are at high risk for poor outcomes.

Table 1: Cox Proportional Hazard Analysis by Diagnosis Type

	Death		Discharge Home		Vent-free Days	
	HR	95% CI; p-value	HR	95% CI; p-value	HR	95% CI; p-value
VAP	1.070	0.67 - 1.74; 0.78	0.44	0.31-0.62; <0.001	-8.11	-7.01 to -9.22; <0.001
VAE	1.91	1.31-2.79; 0.001	0.49	0.35-0.68; <0.001	-9.98	-8.99 to -10.98; <0.001

* Adjusted for race/ethnicity, age, weight, height, ISS, GCS motor, and mechanism of injury

Session: Session XXIII: Papers 58-65
Paper 61: 3:20-3:40 pm

TRAUMA ICU PREVALENCE PROJECT (TRIPP): THE PHENOTYPE OF A TRAUMA ICU. AN AAST MULTI-INSTITUTIONAL STUDY

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Invited Discussant: Bryce Robinson, MD, MSc

Introduction: Specialized trauma ICU (TICU) care has considerable impact on patient outcomes. Few studies describe where and how TICU care is delivered. We hypothesized that assessment of TICU structure and function would uncover strengths, disparities and opportunities to improve surgical critical care delivery in TICUs.

Methods: This was a 1-day, multicenter prevalence study (11/2/17). Participants supplied information about their trauma centers, staff, clinical protocols, and study TICU (ICU where majority of critical trauma patients were admitted).

Results: 27 Level I and 3 Level II trauma centers from across the U.S. participated; 21(70%) had <750 beds and treated 1000-3000 trauma activations/year. Median # of hospital ICU beds was 102. Half were "closed" ICUs and 23 (76%) required an intensivist consult. Ten (33%) ICUs were classified as trauma (>80% of patients were trauma), 15 (50%) surgical/trauma, and 5 (16%) medical-surgical. Intensivists were present 24 hours/ day in 25 (83%). Centers reported a median of 8 [IQR 6.25–10] full-time trauma surgeons and 10 [7-12.75] intensivists. Trauma surgeons' ICU duties comprised 25% of their clinical time and 20% of their overall work time. 97% of ICUs conducted hand hygiene surveillance, 80% used a daily patient care checklist, 86% included families in rounds, 43% had triggers for goals of care discussions, 13% had routine therapist-family meetings, 36% had organized support activities after discharge, and 13% participated in the American Trauma Society's Trauma Survivors Network. Protocol use is listed in the Table.

% Using	Type of Protocol
≥ 90%	Brain death declaration; VTE prophylaxis; stress ulcer prophylaxis; spontaneous breathing trials; massive transfusion; traumatic brain injury (TBI) management
71-90%	Awakening trials; organ donor screening; weight-based VTE prophylaxis; Foley removal; spine clearance; blunt cervical vascular injury (BCVI) workup; red cell transfusion; VTE prophylaxis in TBI patients; ARDS ventilator management
51-70%	VAP diagnosis & antibiotic choice/duration; ventilator management; sedation/analgesia; delirium; patient mobility; treatment of BCVI; novel oral anticoagulant reversal; cuff leak test; Foley insertion; antibiotics for surgical infections
31-50%	Sleep; timing of tracheostomy; fever management/workup; ketamine for non-procedural sedation
≤ 30%	Steroids for airway edema; tranexamic acid for major ortho surgery; triggers for palliative care consult; open abdomen; procalcitonin in VAP or abdominal infections

Conclusion: A survey of structure and function of Trauma ICUs at a sample of high level trauma centers revealed significant variation including care delivery models and protocol use suggesting that opportunities may exist to improve care through sharing of best practices.

Session: Session XXIII: Papers 58-65
Paper 62: 3:40-4:00 pm

Twenty-four hour versus Extended Antibiotic Administration After Surgery in Complicated Appendicitis: A Randomized Controlled Trial

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Invited Discussant: Robert Sawyer, MD

Introduction: A recent prospective investigation suggested that a three-days antibiotic administration was non-inferior to a five-day therapy following appendectomy for complicated appendicitis [1]. Another retrospective investigation noted that 24-hour antibacterial therapy was non-inferior to extended administration [2]. We set out to investigate noninferiority of 24-hour therapy to extended treatment after appendectomy in complicated appendicitis in a pilot randomized controlled trial.

Methods: After IRB approval, all consecutive adult patients with complicated appendicitis (gangrenous, perforated appendicitis, and periappendicular abscess) subjected to appendectomy between 5/2016 and 12/2017 were randomly assigned to antibacterial therapy limited to 24 hours vs. >24 hours (extended administration) after appendectomy. Relevant exclusion criteria were applied. 30-day follow-up was available for all patients. Primary outcomes included post-operative complications and Comprehensive Complication Index (CCI). Secondary outcome was hospital length of stay (HLOS).

Results: A total of 70 patients were enrolled with 34 and 36 cases in the 24-hour and the extended-therapy group, respectively. Demographic profile was similar between the study groups. Laparoscopic appendectomy was performed in 88.2% and 94.4% of patients in the 24-hour and extended group, respectively (p=0.42). Overall rate of complications was 20.6% and 30.6% in the 24-hour and extended group, respectively (OR 1.70; 95% CI 0.57-5.06; p=0.34). Mean CCI did not differ between the study groups (p=0.53). HLOS was significantly reduced in the 24-hour group (61.3 ± 35.7 vs. 81.4 ± 39.6 hours, p=0.03).

Conclusion: In the current prospective randomized investigation, 24-hour post-appendectomy antibiotic administration did not result in a worse primary outcome. However, the 24-hour antibacterial administration resulted in a significant reduction in HLOS with a major cost saving perspective.

References:

1. van Rossem CC et al. Antibiotic Duration After Laparoscopic Appendectomy for Acute Complicated Appendicitis. JAMA Surg. 2015;18:1-7.

2. Kimbrell AR et al. Do postoperative antibiotics prevent abscess formation in complicated appendicitis? Am Surg. 2014;80(9):878-83.

Session: Session XXIII: Papers 58-65
Paper 63: 4:00-4:20 pm

P-SELECTIN IS CRITICAL FOR DE NOVO PULMONARY ARTERIAL THROMBOSIS FOLLOWING BLUNT THORACIC TRAUMA

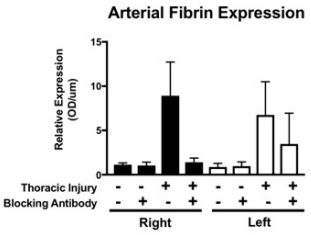
Linda M. Schutzman MD, Ian E. Brown MD,Ph.D., Robert R. Rigor Ph.D., Nasim Khosravi MD, Karen Chung BS, Joseph M. Galante* MD, University of California, Davis

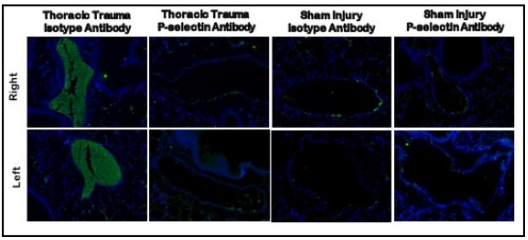
Invited Discussant: Alicia Mohr, MD

Introduction: Thromboembolic events within the pulmonary arterial vasculature are a particularly troublesome complication of severe blunt thoracic trauma. Mechanisms underlying these events are currently in question as pulmonary thromboembolic events in this population tend to be diagnosed more rapidly, more frequently and without an associated systemic thrombosis. This study investigates the role of P-selectin in thrombus formation through the use of in vivo blocking antibodies. We hypothesize that activation of the endothelium and increased P-selectin expression is necessary for *de novo* pulmonary arterial thrombosis in the setting of blunt thoracic trauma.

Methods: A murine weight-drop model of right lateral blunt thoracic trauma was used. Wild-type mice in the experimental group were given blocking antibodies against P-selectin prior to the trauma. All mice were euthanized at 24 hours for evaluation with hematoxylin-eosin staining or immunofluorescent staining for CD41, fibrin and P-selectin.

Results: Injured mice that did not receive the P-selectin antibody had a 7 fold greater fibrin accumulation (fluorescence per um of arterial wall) in comparison to uninjured sham mice. Injured mice that did receive the P-selectin antibody had less than a 2 fold increase than sham controls. Right and left lobes were compared to identify potential differences due to direct versus indirect lung injury. Equal increases in mean fibrin expression were noted on the coup side of injury and the countercoup side. No difference in mean fibrin deposition was found between sham controls that received the P-selectin blocking antibody and those that received an isotype control antibody.





Conclusion:The use of blocking antibodies demonstrates a critical role for P-selectin in early eccentric fibrin accumulation at the intraluminal surface of pulmonary arteries following blunt thoracic trauma.

Session: Session XXIII: Papers 58-65
Paper 64: 4:20-4:40 pm

HIGH PERFORMANCE EMERGENCY GENERAL SURGERY HOSPITALS: GOOD AT ONE OPERATION, GOOD AT THEM ALL

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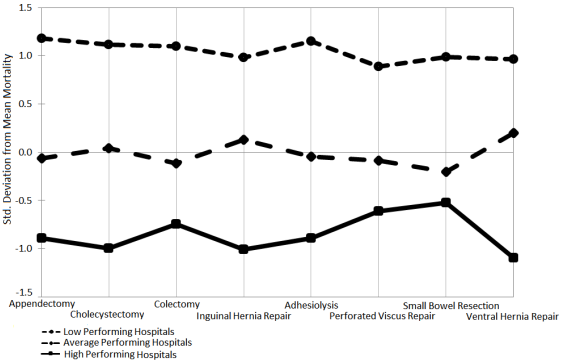
Invited Discussant: Avery Nathens, MD, PhD, MPH

Introduction: There is a longstanding interest in the field of management science to study high performance organizations. Applied to medicine, research on hospital performance indicates that some hospitals are high performing, while others are not. The objective of this study was to identify a cluster of high performing emergency general surgery (EGS) hospitals, and assess whether high performance at one EGS operation was associated with high performance on all EGS operations.
Methods: Adult patients who underwent 1 of 8 EGS operations were identified in the California State Inpatient Database (2010-2011), which we linked to the American Hospital Association database. Beta regression was used to estimate a hospital's risk-adjusted mortality, accounting for patient- and hospital-level factors. Cluster analysis grouped hospitals by pattern of mortality rates across the 8 EGS operations using z-scores. Logistic regression compared hospital characteristics by cluster.
Results: A total of 220 acute care hospitals were included. Three distinct clusters of hospitals (Figure 1) were defined based on assessment of mortality for each operation type: high performing hospitals (n=66), average performing (n=99), and low performing (n=55). The mortality by individual operation type (x-axis in Figure 1) at the high performing cluster was consistently 2 standard deviations better than the low performing cluster ($p<0.001$). Within-cluster variation was minimal at high performing hospitals compared to wide variation at low performing hospitals. A hospital's high performance in one EGS operation type predicted high performance on all EGS operation types.

Figure I. Cluster Peformance Stratified by Operation



Conclusion: High performing EGS hospitals attain excellence across all types of EGS operations, with minimal variability in mortality. Poor performing hospitals are persistently below average, even for low-risk operations. These findings suggest that top-performing EGS hospitals are highly reliable, with systems of care in place to achieve outstanding results. Further investigation and collaboration is needed to identify factors associated with high performance.

Session: Session XXIII: Papers 58-65
Paper 65: 4:40-5:00 pm

THE EGS GRADING SCALE FOR SKIN AND SOFT TISSUE INFECTIONS IS PREDICTIVE OF POOR OUTCOMES : AN AAST MULTI-CENTER VALIDATION STUDY

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Invited Discussant: Eileen Bulger, MD

Introduction: Over the last five years, the American Association for the Surgery of Trauma (AAST) has developed grading scales for Emergency General Surgery (EGS) conditions. An initial validation study was published in 2015, using diverticulitis as a conceptual framework. Though the grading scale was predictive of complications and length of stay, there was no association with mortality. As the EGS grading scales encompass a diverse group of conditions, the purpose of this study was to validate the grading scale concept against a different disease process with a higher associated mortality. We hypothesized that the grading scale would be predictive of complications, length of stay and mortality in skin and soft tissue infections (STI), including necrotizing infections (NSTI).

Methods: This multi-institutional trial encompassed 12 centers. Weighted sampling was used to ensure roughly balanced representation of disease severity. 100 patients were identified from each center and data collection included demographics, disease characteristics and outcomes such as mortality, overall complications, hospital and ICU length of stay. The EGS scale for STI was used to grade each patient and two surgeons provided grades to evaluate inter- rater reliability. Pearson's chi-squares, simple and multiple logistic regressions and ANOVA were used as appropriate. Estimates with 95% confidence intervals were reported and inter-rater reliability was assessed.

Table 1. Complications by EGS grade for skin and soft tissue infections.

	Complications	Length of Stay	ICU Days	Mortality
	Odds Ratio (95% Confidence Interval)			
Grade I (n=312)	ref	ref	ref	ref
Grade II (n = 117)	1.38 (0.68, 2.53)	1.47 (1.34, 1.62)	2.78 (2.06, 3.75)	5.34 (1.21, 23.50)
Grade III (n = 287)	0.79 (0.44, 1.41)	1.33 (1.23, 1.43)	1.64 (1.23, 2.19)	0.66 (0.07, 6.38)
Grade IV (n = 181)	2.13 (1.22, 3.71)	2.89 (2.69, 3.10)	7.98 (6.32, 10.09)	2.65 (0.61, 11.43)
Grade V (n = 243)	2.41 (1.42, 4.08)	3.40 (3.18, 3.63)	9.78 (7.77, 12.31)	15.18 (3.24, 71.12)

Results: 1170 patients were included in this study. Inter-rater reliability was moderate (kappa coefficient 0.472-0.642, with 64-76% agreement). Higher grades (IV and V) corresponded to significantly higher LRINEC scores when compared with lower EGS grades (LRINEC scores : Grade 1 2.55 (SD 2.3), Grade II 2.89 (SD 2.1), Grade III 2.91 (SD 2.3), Grade IV 4.40 (SD 2.4), Grade V 4.72 (SD 2.7), $p < 0.0001$). Patients with grade IV and V STI had significantly increased odds of all complications, as well as ICU and overall length of stay. These associations remained significant in logistic regression controlling for age, gender, comorbidities, mental status and hospital-level volume. Grade V disease was significantly associated with mortality as well (Table 1).

Conclusion: This second validation effort demonstrates continued moderate inter-rater reliability. Grade IV and V STI are significantly predictive of complications, hospital length of stay and Grade V disease was predictive of mortality. Though predictive ability does not improve linearly with STI grade, this is reflective of a relatively dichotomous disease process, in which cellulitis and abscess are milder disease processes and invasive infections are highly morbid. This second validation study confirms the EGS grading scale as predictive, and reproducible, in disparate disease processes.

Session: Session XXV: Papers 66-68: Plenary
Paper 66: 8:00-8:20 am

RESIILIENCE AND LONG-TERM OUTCOMES AFTER TRAUMA: AN OPPORTUNITY FOR EARLY INTERVENTION?

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Invited Discussant: Ben Zarzaur, MD

Introduction: Resilience, or the ability to cope with difficulties, influences an individual's response to life events including unexpected injury. There are early life experiences and biological variables that impact an individual's response to adversity, but research has demonstrated that resilience can be cultivated across the lifespan despite adversity. We sought to assess the relationship between patient self-reported resilience traits and functional and psychosocial outcomes six months after injury.

Methods: Adult trauma patients 18-65 years of age with moderate to severe injuries (ISS ≥9) admitted to one of three Level I Trauma Centers between 2015-2017 were contacted by phone at 6 months post-injury and asked to complete a validated Trauma Quality of Life (T-QoL) survey and PTSD screen. The T-QoL survey assesses emotional and physical well-being at the time of interview, in addition to recovery and resilience. Patients were asked three questions to assess their resilience and the 5-point Likert scale answers were used to classify the patients into "low" or "high" resilience categories (Table 1). Long-term outcomes including functional limitations with activities of daily living, return to work, chronic pain and the incidence of PTSD were compared between groups. Adjusted logistic regression models were built to determine the association between resilience and each of the long-term outcomes.

Table 1: Resilience questions and scoring system

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Q1. I have been able to make changes to handle my current limitations		+0		+1	
Q2. I am more positive about my future than I was before the injury		+0		+1	
Q3. Even though I was injured, my life is better now than it was before the injury		+0		+1	
MIN SCORE = 0; MAX SCORE = 3	**COMPOSITE SCORE 0-1 = LOW RESILIENCE**			**COMPOSITE SCORE 2-3 = HIGH RESILIENCE**	

Results: A total of 222 patients completed the 6-month interview. 149/222 of the patients (67%) were classified in the low resilience group. Mean age was 41±14 years with 65% being male and 91% suffering a blunt traumatic injury. Average ISS was 15.5 ± 8.2 and 41% required ICU admission. Demographic and clinical characteristics were not significantly different between the low and high resilience groups. After adjusting for potential confounders we found that patients in the low resilience group had significantly higher odds of functional limitations in activities of daily living. In addition, patients in the lower resilience group were less likely to have returned to work/school, more likely to report chronic pain and more likely to screen positive for PTSD (Table 2).

Table 2: Long-term outcomes for low vs. high resilience groups

	Adjusted Odds Ratio (95% CI) of outcome compared to high resilience group
Functional limitation in activities of daily living	4.27 (1.94-9.40)
Not yet returned to work/school	2.71 (1.25-5.91)
Chronic pain	3.00 (1.43-6.29)
Positive screen for PTSD	1.89 (1.04-3.45)

*Adjusted for: age, sex, education, injury type, ISS, ICU stay, head injury, previous psychiatric diagnosis

Conclusion: Patients with low resilience demonstrated worse functional and psychosocial outcomes six months after injury. These data suggest that screening for resilience and developing and deploying early interventions to improve resilience-associated traits as soon as possible after injury may hold promise for improving important long-term functional outcomes.

Session: Session XXV: Papers 66-68: Plenary
Paper 67: 8:20-8:40 am

CORRELATION OF ON-CALL TRAUMA SURGEON FATIGUE FLUCTUATIONS WITH BURNOUT RISK AND SURGICAL SKILL PERFORMANCE

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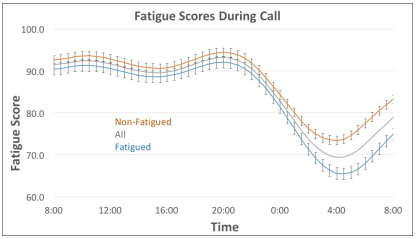
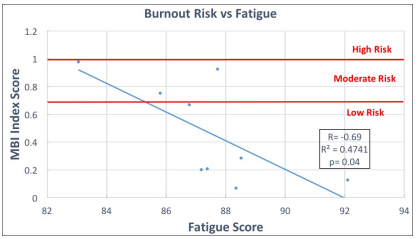
Invited Discussant: Heena Santry, MD

Introduction: Effects of fatigue are thought to be prevalent in the surgical profession, yet descriptive metrics on fatigue are limited. We aimed to quantify trauma surgeon fatigue while on 24-hour call, correlating to surgical task performance and burnout risk. We hypothesize that fatigue levels differ significantly throughout call shifts and worse average fatigue is associated with higher burnout risk and decreased surgical task performance.

Methods: This was a 33 day, prospective, 9 trauma surgeon study at a Level I trauma center. Call shifts were 24 hours. Fatigue was quantified for all subjects from actigraphy monitors utilizing a validated alertness model. Surgeons with scores <70 sustained for >/= 10% total shift time were labeled the "fatigued" group. A laparoscopic peg transfer task was performed, recorded pre/post call and scored based on accuracy. At the end of the trial period each surgeon completed a Maslach Burnout Inventory (MBI) to quantify risk of burnout. Fatigue fluctuations were correlated with time of day, reported work hours, sleep metrics, task performance, and MBI scores. Variables were compared between the "fatigued" and "non-fatigued" groups.



Results: Post call fatigue levels were significantly worse (80.8 vs 90.7, $p<0.001$), more laparoscopic task errors were made ($p=0.05$), and overall task performance decreased ($p=0.05$) compared to pre-call levels. The "fatigued" group had shorter on-call sleep durations (160 vs 286 min; $p = 0.007$) and fatigued at a higher velocity ($p=0.02$) when compared to "non-fatigued" counterparts. Finally, a strong correlation existed between increased MBI burnout risk score and worsened surgeon fatigue ($r = -0.69$, $p = 0.04$). For every one-point worse in fatigue score a surgeon had a 3.5x likelihood of increased risk of burnout. There was no significant difference between groups in regards to hours worked or sleep obtained three days prior to call.



Conclusion: Trauma surgeons experience a significant increase in fatigue during a 24-hour call shift, average level of surgeon fatigue is highly correlated with self-assessment of burnout risk, and a trauma surgeon's ability to perform a surgical task is significantly worse after a 24-hour call shift. Future studies can expand this investigational work to better understand the impact of trauma surgeon fatigue.

Session: Session XXV: Papers 66-68: Plenary
Paper 68: 8:40-9:00 am

STOP FLAILING: THE IMPACT OF BICORTICALLY DISPLACED RIB FRACTURES ON PULMONARY OUTCOMES IN PATIENTS WITH CHEST TRAUMA - AN AAST MITC STUDY

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Invited Discussant: Fredric Pieracci, MD, MPH

Introduction: Most studies examining outcomes related to thoracic trauma focus on the presence or absence of flail chest, pulmonary contusion, hemothorax or pneumothorax with little attention paid to bicortically displaced rib fractures. An association between bicortical fractures and pulmonary outcomes such as pneumonia, ARDS and the need for tracheostomy would influence care decisions. We therefore tested the hypothesis that bicortical rib fractures were an important clinical marker for pulmonary outcomes in **non-flail** chest trauma patients.

Methods: This AAST-MITC retrospective study analyzed bluntly injured adults with at least 2 rib fractures collected from 9 US level I and II trauma centers from 2011 to 2016. Each chest CT was independently reviewed and the location and severity of rib fractures and pulmonary contusions were categorized. Univariate and multivariate logistic regression analyses were performed to identify independent predictors of pneumonia, ARDS and tracheostomy. Analyses were performed in non-flail patients as well as controlling for flail chest to determine if bicortical fractures were independently associated with pulmonary outcomes.

Results: Of the 1110 patients 103 (9.3%) developed pneumonia, 78 (7.0%) required tracheostomy, and 30 (2.7%) developed ARDS. Bicortical fractures were present in 277 (25%) of all patients and in 206 (20.3%) of patients without flail chest. After adjusting for patient demographics, injury and admission physiology, negative pulmonary outcomes occurred more than twice as frequently in those with bicortical displacement **without** flail chest - pneumonia (OR 2.01, 95% CI 1.1, 3.6), ARDS (OR 2.62, 95% CI 1.01, 6.82) and tracheostomy (OR 2.7, 95% CI 1.4, 5.2). Even when adjusting for the presence of flail chest, bicortical displacement remained an independent predictor of pneumonia, tracheostomy and ARDS.

Conclusion: Given that bicortical displacement can be difficult to identify on plain radiography and its association with negative pulmonary outcomes, even in the **absence** of flail chest, chest CT should be employed in the evaluation of rib fractures. Future studies should investigate the utility of flail chest management algorithms such as epidural and surgical stabilization on pulmonary outcomes in patients with bicortical displacement.