Session I: Plenary Papers 1-9
Paper 1: 9:30 AM - 9:50 AM

AFTER 800 MTP EVENTS, MORTALITY DUE TO HEMORRHAGIC SHOCK REMAINS HIGH AND UNCHANGED DESPITE SEVERAL HEMORRHAGE CONTROL ADVANCEMENTS; IS IT TIME TO MOVE THE PENDULUM?

Juan C. Duchesne MD, Chrissy Guidry MSc, DO, Charles Harris MD, Sharven Taghavi MD, Rebecca Schroll MD, McGrew Patrick MD, Clifton McGinness MD, Danielle Tatum PhD
Tulane School of Medicine

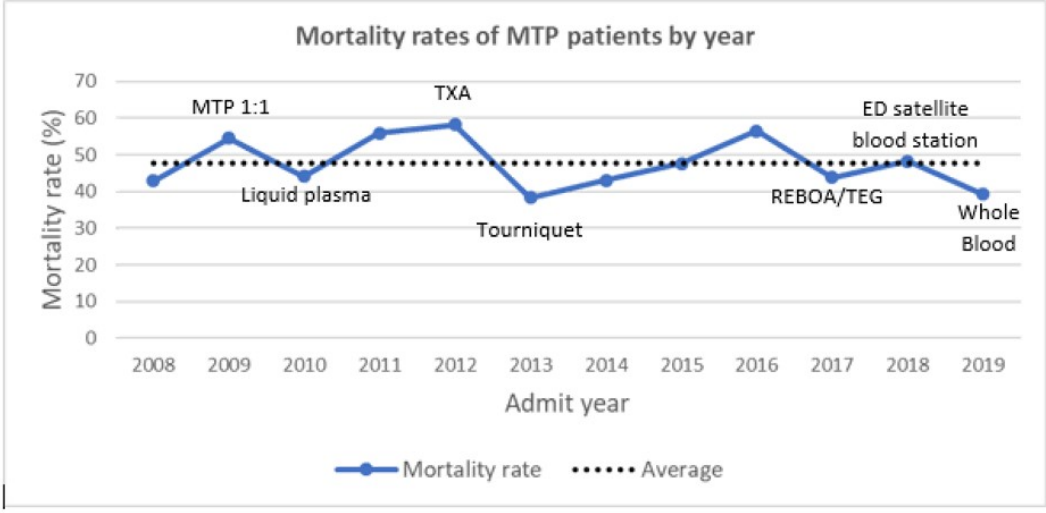
Invited Discussant: Jeremy Cannon, MD

Introduction: Numerous advancements in hemorrhage control have been implemented in the last decade, including balanced massive transfusion protocol (MTP), re-emergence of tourniquets, thromboelastography (TEG), and resuscitative endovascular balloon occlusion of the aorta (REBOA). We examined the effect of these interventions and others in an MTP population and hypothesized that mortality would be decreased in later years, which would have utilized many of these advancements.

Methods: This was a retrospective review of all MTP patients treated at a large regional Level I trauma center from 2008 – 2019. Interventions by year of implementation examined included MTP 1:1 ratio (2009), liquid plasma (2010), tranexamic acid (TXA) (2012), tourniquets (2013), REBOA/ TEG (2017), ED satellite blood station (2018), and whole blood transfusion (2019).

Results: There were 824 MTP patients included. The cohort was primarily male (80.6%), African American (70.1%), injured by penetrating mechanism (68.1%) with median (IQR) age 31 years (23 – 44) and ISS 25 (16 – 34). Overall mortality was 52.8% with no difference in ISS ($P = 0.10$). During the 12-year analysis the overall mortality per year was unchanged 38.3% to 56.6% ($P = 0.26$). Pre-hospital transport time did differ significantly ($P < 0.001$) with the longest median times in 2018 and 2019 but was not associated with increase in-hospital mortality ($P = 0.15$). Although no intervention when examined by logistic regression was significantly associated with mortality reduction, the implementation of tourniquet and whole blood transfusion conveyed the lowest in-hospital mortality.

Conclusions: Despite significant advancements in damage control resuscitation and volume preservation strategies, mortality rates due to severe hemorrhage have not improved in the past 12 years at our high MTP volume institution. This suggests that implementation of new in-hospital strategies is insufficient to move the pendulum of mortality. Future efforts should be directed towards moving targeted hemorrhage control and effective resuscitation interventions to the injury scene.



Session I: Plenary Papers 1-9
Paper 2: 9:50 AM - 10:10 AM

DYNAMIC USE OF FIBRINOGEN UNDER VISCOELASTIC ASSESSMENT RESULTS IN REDUCED NEED FOR PLASMA AND DIMINISHED OVERALL TRANSFUSION REQUIREMENTS IN SEVERE TRAUMA

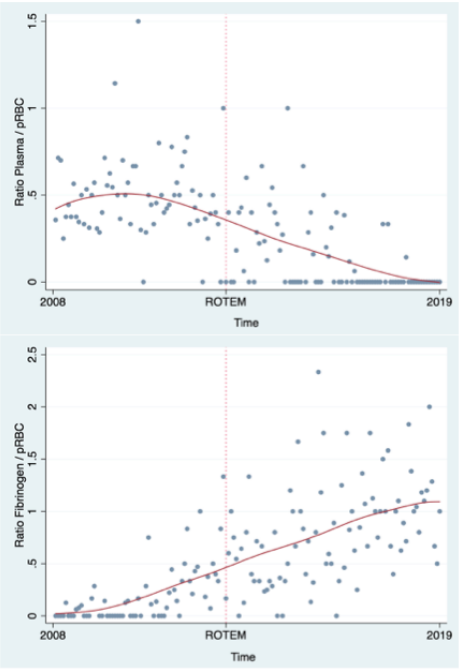
Marta Barquero Lopez MD, Javier Martinez-Cabanero MD, Clara Saez MD, Marta De la Rosa-Estadella MD, Alejandro Munoz-Valencia MD, Aurora Gil MD, Gemma Pujol MD, Andrea Campos-Serra MD, Salvador Navarro-Soto MD, PhD, Juan Carlos Puyana MD
Bellvitge University Hospital

Invited Discussant: Mitchell Cohen, MD

Introduction: Hypofibrinogenemia is a major component of Trauma Induced Coagulopathy (TIC) and it is associated with increased transfusion needs and mortality. Fibrinogen concentrate (FC) has advantages, as thawing is not necessary and it obviates the need for blood type compatibilities. Our understanding of the implementation of a fibrinogen based protocol resuscitation guided by hemostatic competency monitoring (ROTEM™) has resulted in a reduction of the use of plasma. We hypothesized that the use of FC reduces use of blood products and outlined the evolution of our resuscitation strategy over time.

Methods: We identified 150 severe trauma patients (January 2008-July 2019), all patients requiring a minimum of 3 packed red blood cells (pRBCs) within the first 24 hours. We established three treatment groups, reflecting a different stage in the evolution of our strategy (n=135, overlapped in time n=15): plasma (P), plasma and fibrinogen concentrate (PF) and only fibrinogen concentrate (FC). Linear regression analyses were conducted.

Results: Group P had 28 patients, PF=65 and FC=42. There were no significant differences in mechanism of trauma, ISS and physiological status upon arrival. Progressive implementation of ROTEM™ resulted in a significantly increased use of FC over time (use of ROTEM™ in P group 0%, PF group 49.23%, FC group 100%; $p < 0.001$). A regression model showed significant differences in the number of pRBCs transfused within the first 24 hours, (P group 9.5, PF group 11.62, FC group 7.48; p=0.005). The number of patients who required platelets transfusion within 24 hours was significantly lower in the FC (P 57.14%, PF 73.85%, FC 45.24%; p=0.01). A total of 11 patients (26.19%) in the FC needed supplementation with prothrombin complex concentrate (mean dose 1000UI), versus P = 0% and PF = 15.38%, p=0.012. FC patients had less pneumonia (P 35%, PF 42.5%, FC 12.9%; p=0.019) and multi-organ failure (P 60%, PF 35%, FC 6.5%; $p < 0.001$). No differences were observed for sepsis, ARDS, AKI or thromboembolic events, mechanical ventilation days, ICU days and length of hospitalization. Overall mortality was not significantly different among the three groups (P 35.71%, PF 44.62%, FC 30.95%). However, a separate analysis comparing exclusively the mortality due to massive hemorrhage in the FC group [n=6/53 (11.32%)] versus all patients receiving plasma [P+PF combined n=25/97 (25.77%)] was significantly different p=0.037. Figures outline use of blood products over time.



Conclusion: Titrated reposition with FC under viscoelastic monitoring resulted in a significant reduction of pRBCs transfused within 24 hours. Supplemental dose of coagulation factors was required in 26.19% of FC. This protocol was associated with a decreased incidence of pneumonia, multi-organ failure, and reduced mortality in patients with massive hemorrhage.

Session I: Plenary Papers 1-9
Paper 3: 10:10 AM - 10:30 AM

PLASMA RESUSCITATION WITH ADJUNCTIVE PERITONEAL RESUSCITATION REDUCES ISCHEMIA INDUCED INTESTINAL BARRIER BREAKDOWN FOLLOWING HEMORRHAGIC SHOCK

Jason W. Smith MD,PhD,MBA, **Jessica Schucht MD,** Brian G. Harbrecht MD, Paul Matheson PhD
University of Louisville

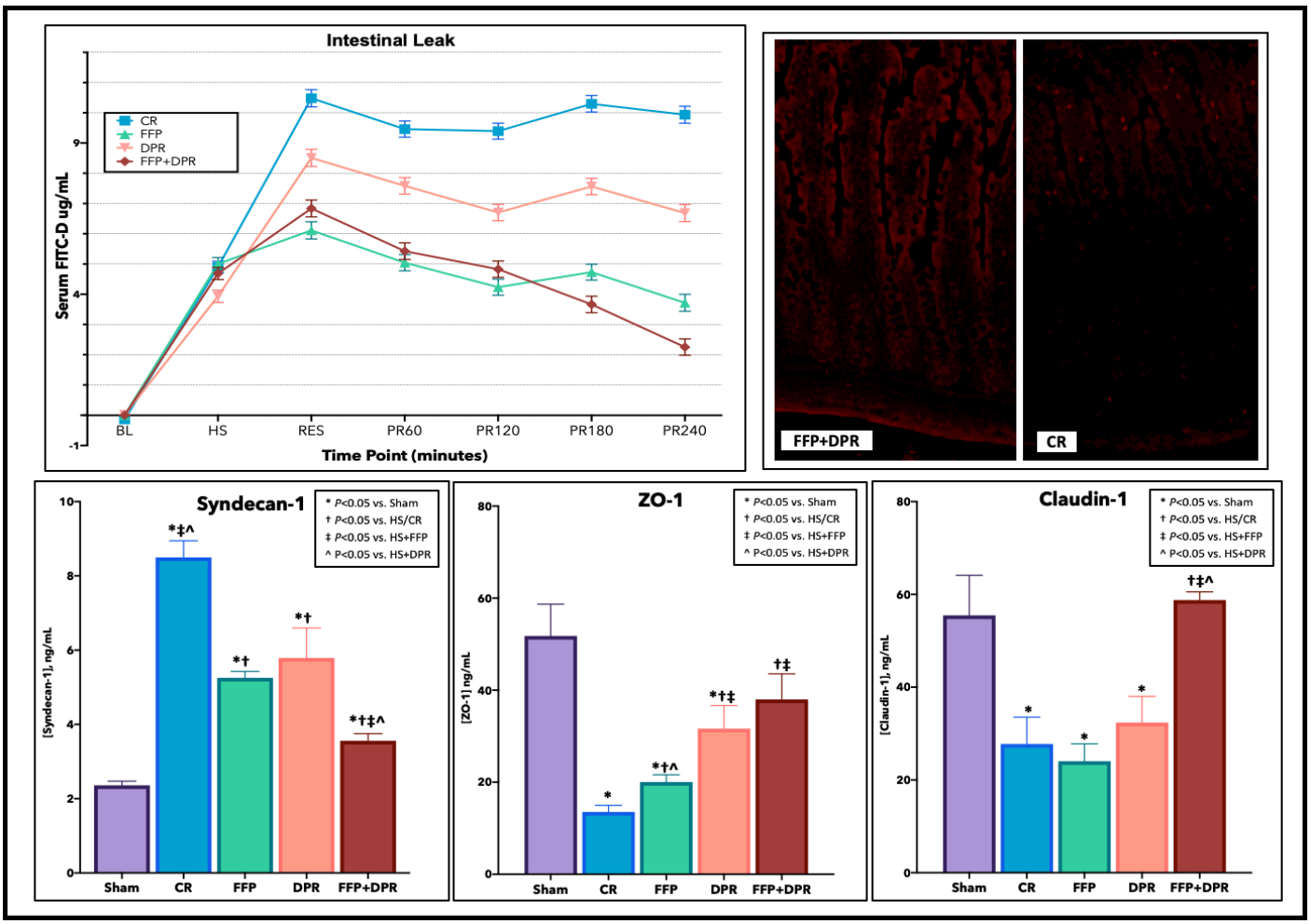
Invited Discussant: Donald Jenkins, MD

Introduction: Hemorrhagic shock and resuscitation (HS/RES) leads to an ischemia induced increase in intestinal permeability. This results from intestinal barrier breakdown, damage to the endothelium, and disruption of tight junction (TJ) complex between enterocytes. It is unclear how hemostatic resuscitation (with blood products) following HS may affect this phenomenon. We previously demonstrated that resuscitation with Fresh Frozen Plasma (FFP) with and without Directed Peritoneal Resuscitation (DPR) improves blood flow and alleviates signs of organ injury and enterocyte damage following HS. We postulate these findings would translate into decreased tight junction injury and attenuated ischemia induced permeability across the intestine following HS.

Methods: Sprague Dawley rats underwent HS(40% mean arterial pressure) for 60-minutes and randomly assigned to a resuscitation group (n=8): ***Sham*; Crystalloid Resuscitation** (CR) (shed blood+two volumes CR); ***CR +DPR*** (intraperitoneal 2.5% peritoneal dialysis fluid (IP)); ***FFP*** (shed blood+two volumes FFP); ***FFP+DPR*** (IP dialysis fluid+two volumes FFP). FITC-Dextran was instilled into the GI tract prior to hemorrhage; UV spectrometry was used to measure serum levels at various time points. Plasma syndecan-1 and ileum tissue concentrations of TJ proteins were measured using ELISAs. Immunofluorescence was used to visualize claudin-4 concentrations at 4-hours following HS/RES.

Results: Following HS, FFP attenuated FITC-Dextran leak across the intestine at all time points compared to CR and DPR alone. This response was significantly improved with the adjunctive DPR at 3-and 4-hours post-resuscitation ($p < 0.05$) (Figure 1). Resuscitation with FFP+DPR increased intestinal tissue concentrations of TJ proteins and decreased plasma syndecan-1 (Figures 3-5). Immunofluorescence demonstrated decreased mobilization of claudin-4 in both FFP and FFP+DPR groups (Figure 2).

Conclusion: FFP based resuscitation improves intestinal tight junction and endothelial integrity. The addition of DPR can further stabilize TJs and attenuate intestinal permeability. Combination therapy with DPR and FFP to mitigate intestinal barrier breakdown following shock could be a novel method of reducing ischemia induced intestinal permeability and systemic inflammation after trauma.



Session I: Plenary Papers 1-9
Paper 4: 10:30 AM - 10:50 AM

INFLATE AND PACK! PELVIC PACKING COMBINED WITH REBOA DEPLOYMENT PREVENTS HEMORRHAGE RELATED DEATHS IN UNSTABLE PELVIC FRACTURES

Clay C. Burlew MD, Julia R. Coleman MD, MPH, Mari Freedberg MD, MSc, Alicia Heelan Gladden MD, Ernest E. Moore MD, Cyril Mauffrey MD, Melanie Hoehn MD, K B. Platnick MD, Mitchell J. Cohen MD, Jamie J. Coleman MD, Eric Campion MD, Ryan Lawless MD, Nicole Werner MD, Alexis Cralley BS, Fredric M. Pieracci MD, MPH
Denver Health Medical Center

Invited Discussant: Carrie Sims, MD

Introduction: Resuscitative endovascular balloon occlusion of the aorta (REBOA) has been advocated for hemorrhage control in pelvic fracture patients in shock. We evaluated REBOA use in patients undergoing pelvic packing (PP) for pelvic fracture hemorrhage.

Methods: Since 2004 our management for pelvic bleeding with hemodynamic instability despite 2 units red blood cells (RBCs) is PP. In 2015 REBOA was considered for systolic blood pressure < 80mmHg.

Results: During the study period (January 2015 - January 2019), 652 pelvic fracture patients were admitted; 78 consecutive patients underwent PP. Median RBCs at PP completion compared to 24 hours post-packing were 11 versus 3 units ($p < 0.05$). Median time to operation was 65 minutes. After PP, 7 (9%) patients underwent angioembolization.

Patients who received REBOA had a significantly higher injury severity score, lower SBP, and higher heart rate (Figure 1). Despite severe injury there were no deaths due to pelvic fracture-related hemorrhage. Overall mortality in this high-risk group was 14%. For the 11 patients that died, life sustaining support was withdrawn, most commonly due to neurologic insults (TBI/fat emboli = 6, stroke/spinal cord injury = 3).

Conclusion: PP with REBOA was utilized in more severely injured patients with greater physiologic derangements. Although REBOA patients required greater transfusion requirements, there were no deaths due to acute pelvic hemorrhage. This suggests the combination of REBOA with PP provides life-saving hemorrhage control in otherwise devastating injuries.

Variable	REBOA (+) (n=31)	REBOA (-) (n=47)	P-Value
Age (years)	45.4 (18-89)	46.8 (13-80)	0.72
Male (%)	23 (74.2%)	32 (68.1%)	0.56
Injury Severity Score (ISS)	**48.8 (29-75)**	**39.6 (16-75)**	**<0.01****
Emergency Department			
Systolic Blood Pressure (SBP)	**64.5 (50-84)**	**71.9 (41-113)**	**0.02****
Heart Rate	**129 (62-179)**	**117 (51-168)**	**0.04****
Time in ED	51 (16-217)	76 (0-290)	0.07
Red Blood Cells (RBCs)	3 (1-11)	4 (0-13)	0.31
Additional Procedures	2.6 (0-9)	2.1 (0-9)	0.25
RBCs pre-ICU	**16 (2-44)**	**7 (2-21)**	**<0.01****
RBCs subsequent 24 hours	3 (0-15)	3 (0-25)	0.81
FFP pre-ICU	**9 (0-39)**	**4 (0-16)**	**<0.01****
FFP subsequent 24 hours	2 (0-13)	2 (0-10)	0.36
Pelvic infection (%)	1 (4.4%)	1 (3.3%)	0.81
Alive (%)	26 (83.9%)	41 (87.2%)	0.68

CRITICAL CARE ULTRASOUND IN GERIATRIC TRAUMA RESUSCITATION LEADS TO DECREASED FLUID ADMINISTRATION AND VENTILATOR DAYS

Elaine M. Cleveland MD, Y. Everett Warren MD, Rathna Shenoy MD, Margaret Lewis MD, Kyle Cunningham MD, MPH, Huaping Wang PhD, Rita Brintzenhoff MD
Atrium Health Carolinas Medical Center

Invited Discussant: Paula Ferrada, MD

Introduction: Geriatric trauma populations respond differently than younger trauma populations. Critical Care Ultrasound (CCUS) can guide resuscitation, and has been shown to decrease intravenous fluid (IVF), lower time until operation, and lower mortality in trauma. CCUS guided resuscitation has not yet been studied in geriatric trauma. We hypothesized that incorporation of CCUS into the resuscitative strategy of geriatric trauma patients would decrease amount of IVF administered, decrease time to initiation of vasopressors, and decrease end organ dysfunction.

Methods: A PRE-CCUS geriatric trauma group was identified and resuscitated per standard practice. A POST-CCUS group was identified and resuscitated based on CCUS performed by trained intensivist upon admission to the ICU and 6 hours after initial ultrasound. The PRE-CCUS and POST-CCUS groups underwent propensity score matching based on injury severity score (ISS), age, and gender, yielding 60 enrollees in each arm. Retrospective review was conducted on both groups including demographics, clinical outcomes, and primary endpoints including amount of IVF in the first 48 hours, duration to initiation of vasopressor use in the first 48 hours, and end organ dysfunction. Wilcoxon two-sample, chi-square tests, and Kappa statistics were performed to check associations between groups.

Results: There was no statistical difference between PRE-CCUS and POST-CCUS with regards to demographics and ISS scores. IVF‘s within 48 hours decreased from median [interquartile range] 4941mL[4019mL] in the PRE-CCUS group to 2633mL[3671mL] in the POST-CCUS group ($p=0.0003$). There was no significant difference between the two groups in the time to initiation of vasopressor therapy, pressor duration, lactate clearance, ICU length of stay, or hospital length of stay. There was a significant decrease in prolonged ventilation, with 26.7% of patients in the PRE-CCUS requiring ventilation > 2 days, and only 6.7% of patients in the POST-CCUS group requiring ventilation > 2 days ($p=0.0033$). While not statistically significant, there was a decrease in mortality rates, with 10.0% mortality in the PRE-CCUS group and 3.3% in the POST-CCUS group.

Conclusions: CCUS can be a useful addition to resuscitation strategies in geriatric trauma. The POST-CCUS group received less IV fluid and had a decreased frequency of prolonged ventilator days. While mortality, lactate clearance, complications, and hospital stay were not statistically different, there was a perception that CCUS was a useful adjunct for assessing volume status and cardiac function in the geriatric population.

OUTCOMES OF STANDARDIZED NON-OPERATIVE MANAGEMENT OF HIGH-GRADE PANCREATIC TRAUMA IN CHILDREN: A STUDY FROM THE PEDIATRIC TRAUMA SOCIETY PANCREATIC TRAUMA STUDY GROUP

Bindi Naik-Mathuria MD, MPH, Richard A. Falcone, Jr. MD, Peter Ehrlich MD, Brendon Campbell MD, Robert Russell MD, Marianne Beaudin MD, Chad Hamner MD
Baylor College of Medicine

Invited Discussant: Kathryn Bass, MD

Background: Non-operative management (NOM) for pancreatic trauma with duct disruption has been shown to be variable among pediatric trauma centers, and outcomes are unclear regarding optimal management for these rare injuries. Our group proposed a "Less is More" NOM clinical pathway in 2017 to standardize management that recommends early oral feeding, limited imaging and labs, and discharge based on symptom improvement. The purpose of this study is to assess outcomes of patients who were managed by this pathway.

Method: Prospective, multicenter study of seven pediatric trauma centers (2018-2019). Children with blunt pancreatic injury with duct disruption (AAST grade III) who presented within 48 hours of injury were managed per the NOM clinical pathway and short and long-term outcomes were collected prospectively. Outcomes were compared to a historical cohort from thirteen centers prior to protocol implementation (2010-2015).

Results: Of 11 patients, the median age was 7 years (range 12 months-15 years). Handlebar injury was the most common mechanism (7/11, 64%). Clear liquid diet was started at mean 3.5 days (range 1-14) and low-fat diet at 6.7 days (range 2-24). Three patients (27%) failed diet advancement and required TPN or jejunal feeds. Endoscopic pancreatic duct stent was placed in 3/11 patients (27%). Mean length of stay (LOS) was 9.9 days (range 2-41). One patient who had pancreatic ascites at presentation developed a symptomatic pseudocyst that required endoscopic cyst-gastrostomy and developed exocrine pancreatic insufficiency. There were no other complications, additional interventions or hospitalizations.

Compared to the historical cohort (32 patients), TPN use was significantly lower (pre-protocol 56% vs post 18%, p=0.03) and organized fluid collection/pseudocyst was also lower (pre-protocol 81% vs post 18%, p=0.0004). Time to tolerating low-fat diet was shorter (pre-protocol 11.6 days vs post 6.7 days) and LOS was shorter (pre-protocol 13.6 days vs post 9.9 days), but neither were statistically significant.

Conclusion: Children with pancreatic injury with duct disruption can be safely managed and have rapid recovery using the "Less is More" standard NOM clinical pathway. Pancreatic ascites at presentation may be an indication to consider operative management or expect prolonged recovery with NOM. Further study is needed.

Session I: Plenary Papers 1-9
Paper 7: 11:30 AM - 11:50 AM

ANTIPLATELET AND ANTICOAGULANT AGENTS, ALONE AND IN COMBINATION, HAVE MINIMAL IMPACT ON TRAUMATIC BRAIN INJURY (TBI) INCIDENCE, NEED FOR SURGERY, AND MORTALITY IN GERIATRIC GROUND LEVEL FALLS (GLFS): A MULTI-INSTITUTIONAL ANALYSIS OF 33,710 PATIENTS

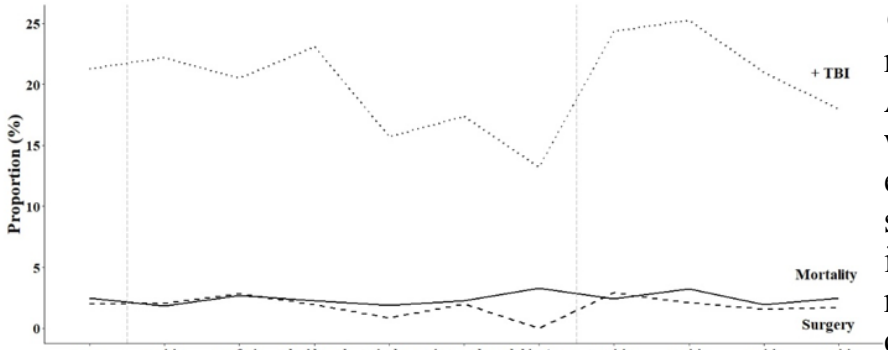
Samir M. Fakhry MD, Jennifer Morse, Jeneva Garland, Nina Wilson, Dorraine Watts PhD
Center for Trauma and Acute Care Surgery Research, CSG, HCA Healthcare

Invited Discussant: Scott Sagraves, MD

Introduction: Falls are the leading cause of TBI and TBI-related deaths for older persons (age>65). Antiplatelet and/or anticoagulant therapy (antithrombotics, ATs) is generally felt to increase this risk, but the literature is inconsistent. The purpose of this study was to determine the impact of AT use on the rate, severity and outcomes of TBI in older patients following GLFs.

Methods: GLF patients from 90 hospitals' trauma registries were selected. Patients were excluded if <65 years or had an AIS > 2 in a region other than head. EMR data for preinjury AT therapy were obtained. Patients were grouped by regimen for no AT, single, or multiple agents. Groups were compared on rates of diagnosed TBI, TBI surgery, and mortality.

Results: TThere were 33,710 patients (35% male, mean age 80.5, mean GCS 14.6), with 47.6% on single or combination AT therapy. The proportion of TBI diagnoses did not differ between those on No AT (21.25%) vs AT (21.61% p=0.418). Apixaban (15.7% p<0.001) and Rivaroxaban (13.19% p=0.011) were associated with lower rates of TBI, and ASA + Clopidogrel was associated with a higher TBI rate (24.34% p=0.002) vs. No AT. ASA + Clopidogrel was associated with a higher cranial surgery rate (2.9% p=0.006) vs No AT (1.96%), but surgery rates were similar for all other regimens. No regimen was associated with higher mortality.



	none n=17679	aspirin n=6721	warfarin n=1630	clopidogrel n=1339	apixaban n=1064	rivaroxaban n=754	dabigatran n=182	aspirin clopidogrel n=1968	aspirin warfarin n=618	aspirin apixaban n=519	aspirin rivaroxaban n=245
+ TBI	21.25%	22.2%	20.49%	23.08%	*15.7%**	17.37%	*13.19%**	*24.34%**	25.24%	21%	17.96%
Surgery	1.96%	2.01%	2.82%	1.94%	0.85%	1.99%	0%	*2.9%**	2.1%	1.54%	1.63%
Mortality	2.48%	*1.82%**	2.7%	2.24%	1.88%	2.25%	3.3%	2.39%	3.24%	1.93%	2.45%

** Group is statistically significantly different from No Antithrombotic Group (p<.01)*

Conclusions: In this large, multicenter study, the intake of ATs in older patients with GLFs was associated with inconsistent effects on risk of TBI and no significant increases in mortality, indicating AT use may have negligible impact on patient clinical management. A large, confirmatory, prospective study is needed, as the commonly held belief that ATs uniformly increase the risk of traumatic intracranial bleeding and mortality is not supported.

MEAN ARTERIAL PRESSURE MAINTENANCE FOLLOWING SPINAL CORD INJURY: DOES MEETING THE TARGET MATTER?

Jordan A. Weinberg MD, Kristina Chapple PhD, Louay Kalamchi BS, Harrison Farber MD, Scott Brigeman MD, Michael Bohl MD, Bianca Varda BS, Natasha Sioda BS, John Radosevich, Laura Snyder MD
Dignity Health, St. Joseph's Hospital and Medical Center

Invited Discussant: Deborah Stein, MD, MPH

Introduction: Neurosurgical guidelines recommend maintaining mean arterial pressure (MAP) between 85–90 mmHg following acute spinal cord injury (SCI). This is accomplished with intensive blood pressure monitoring and MAP augmentation with vasopressors as needed to maintain MAP at or above 85 mmHg. In our hospital, SCI patients receive orders for MAP maintenance for 72 hours following admission, but it is unclear how often the patient's MAP meets the target and whether or not this affects outcome. We hypothesized that the relative proportion of MAP measurements meeting the target of 85 mmHg (MAP85) would be associated with extent of neurologic recovery by hospital discharge.

Methods: SCI patients admitted between 2014 and 2019 were identified from the registry of a level 1 trauma center. Sequential MAP values for the first 72 hours from admission were obtained from electronic medical record review. The proportion of MAP85 was calculated for each patient. Cumulative vasopressor dose (norepinephrine equivalent) for first 72 hours within admission was recorded. Neurologic improvement, as measured by positive change in ASIA Impairment Scale by at least one level from time of admission to discharge, was evaluated with respect to proportion of MAP85.

Results: 136 SCI patients: 102 were male with median ISS 24 (17 – 27) and hospital LOS 10.4 days (6.6 – 15.5). Average number of MAP recordings for all patients was 157.0±70.4 and average proportion of MAP85 was 71.5%. 103 (81.4%) patients required vasopressors to elevate MAP (ASIA A 80.6%; B 95%; C 93%; D 59%). Median norepinephrine-equivalent dose was 25.9 mg (11.7 – 47.4). Admission ASIA scores were: A 31(22.8%), B 20(14.7%), C 27(19.9%), and D 58(42.6%). 41 patients (30.1%) were observed to have improvement in ASIA score by discharge (admission ASIA A 17%; B 32%, C 39%, D 12%). Proportion of MAP85 was higher for patients with ASIA improvement (79% ± 14 vs 68% ± 25, $p = 0.002$). Multivariate logistic regression modeling, adjusted for central cord syndrome, vasopressor dose, ISS, and admission ASIA score demonstrated a significant association between proportion of MAP85 and neurologic improvement of at least one ASIA level ($p = 0.020$).

Conclusion: The proportion of MAP measurements meeting the target of 85 mmHg was determined to be an independent predictor of neurologic improvement. Nonetheless, despite the intention of maintaining MAP above 85 mmHg for the first 72 hours of admission, the proportion of MAP measurements below the target during this period was nearly 30% on average. Increased vigilance regarding MAP maintenance above 85 mmHg is warranted to optimize neurologic recovery following SCI.

Session I: Plenary Papers 1-9
Paper 9: 12:10 PM - 12:30 PM

FIREARM STORAGE PRACTICES OF U.S. MEMBERS OF THE AMERICAN COLLEGE OF SURGEONS

Deborah A. Kuhls MD, Brendan T Campbell MD, Eileen M. Bulger MD, Ronald M. Stewart MD
UNLV School of Medicine

Invited Discussant: Tracey Dechert, MD

Introduction As a part of its firearm injury prevention action plan, the American College of Surgeons (ACS) surveyed the entire US ACS membership regarding individual member's knowledge, experience, attitudes, degree of support for ACS COT firearm programs, and degree of support for a range of firearm injury prevention policies. This survey included questions regarding members' prevalence of firearm ownership, type of firearm(s) in the home, personal reasons for firearm ownership and methods of firearm/ammunition storage.

Methods An email invitation to participate in an anonymous, 23-item survey on firearms was sent to all US ACS members (n= 54,761) by a contracted survey research firm. Cross tabulation of questionnaire items by demographic characteristics and chi-square analyses were performed with statistical significance $p < 0.05$.

Results The overall response rate was 20.4% (11,147/54,761). Forty-two percent of respondents keep firearm(s) in their home (82%long guns, 82% handguns; 32% high-capacity magazine fed, semi-automatic rifle); 75% own for self-defense/protection, 73% for target practice; 39% store firearms unlocked and 32%store them unlocked and loaded. Results vary by practice/training location, practice type, military experience, gender, age, presence of children in the home, level of training and race/ethnicity.

Conclusion Significant percentages of ACS members store firearms in their home and about 1/3 store firearms in an unlocked *and* loaded fashion. Safe storage is a tenet of responsible firearm ownership. These data present opportunities for engaging surgeons in efforts to improve safe firearm storage in homes.

Table 1: Storage Practices of ACS Members Groups (%)

Storage Status N	Gen Surg 5121	Other Surg 4241	Mil Exp 2406	No Mil Exp 8726	Female Gender 2347	Male Gender 8777	Child in Home 4046	No Child in Home 7014	Resident Member 1904	FACS Member 6896	Retired Member 1102
Store in Home	41	41	59*	38*	26*	47*	40*	42*	24*	47*	58*
Unlocked	39*	32*	46*	36*	34*	39.6*	26*	46*	42*	36*	53*
Unlocked & Loaded	33*	28*	39*	29*	26*	32.9*	21*	38*	33*	31*	40*

Abbreviations: Gen Surg: General Surgery, Mil Exp: Military Experience, FACS: ACS Fellow *p < 0.05

Table 2: Storage Practices of ACS Members By Race/Ethnicity (%)

Storage Status N	White Race 8579	African American 283	Hispanic /Latino 393	Female Gender 2347	Asian/Asian American 986	Mid Eastern/ North African 200	Multi-Racial 443
Store in Home	47*	23*	33*	26*	18*	13*	35*
Unlocked	40*	37*	30*	34*	30*	17*	31*
Unlocked & Loaded	32*	35*	41*	26*	23*	28*	31*

*p < 0.05

Session II: Plenary Papers 10-13
Paper 10: 1:00 PM - 1:20 PM

ANTITHROMBIN III AMELIORATES POST-TBI CEREBRAL LEUKOCYTE-ENDOTHELIAL CELL INTERACTIONS AND BLOOD BRAIN BARRIER (BBB) PERMEABILITY IN VIVO

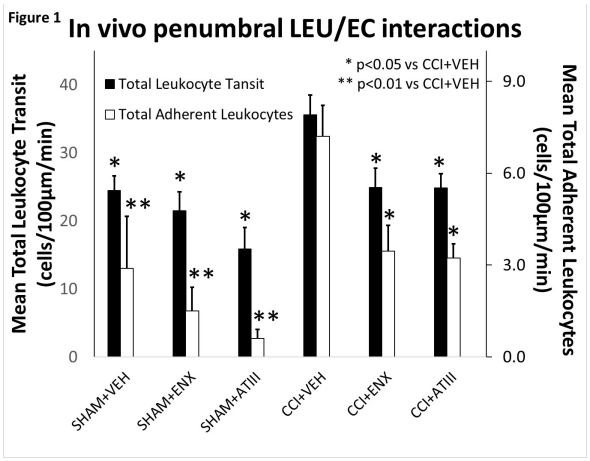
Mohamed Elsaadani MD, Syed Ahmed MD, Christina Jacovides MD, Alfonso Lopez MD, Victoria Johnson PhD, Lewis J. Kaplan MD, C. William Schwab MD, Douglas Smith MD, Jose L. Pascual MD, PhD
Hospital of the University of Pennsylvania

Invited Discussant: Hasan Alam, MD

Introduction: Acute traumatic coagulopathy often accompanies traumatic brain injury (TBI) and may impair cognitive recovery. Antithrombin III (ATIII) reduces the hypercoagulability of TBI. ATIII and heparinoids such as enoxaparin (ENX) demonstrate potent anti-inflammatory activity, reducing organ injury and modulating leukocyte (LEU) activation, independent of their anticoagulant effect. It is unknown what impact ATIII exerts on cerebral LEU activation and BBB permeability after TBI. We hypothesized that ATIII reduces live microcirculatory LEU-endothelial (EC) interactions and leakage at the BBB following TBI.

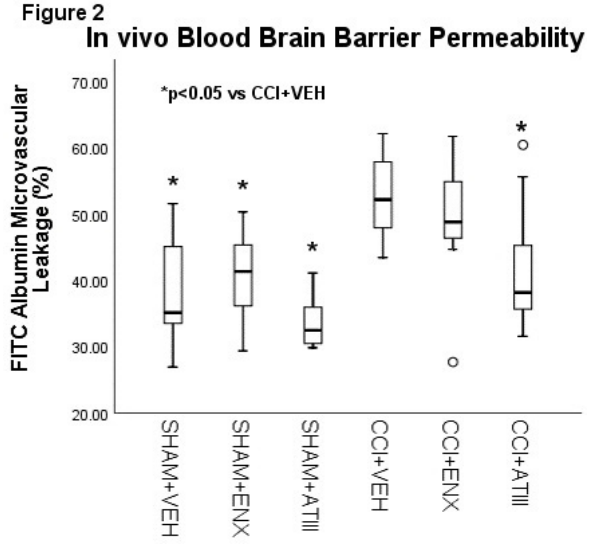
Methods: CD1 mice (n=71) underwent either severe TBI (controlled cortical impact; CCI: 6 m/sec velocity, 1 mm depth and 4 mm diameter) or sham craniotomy (SHAM) and then received either ATIII (250 IU/kg), ENX (1.5mg/kg) or VEH (saline) every 24h. 48 hours post-TBI, cerebral intravital microscopy visualized *in-vivo,* penumbral microvascular EC-L interactions and microvascular leakage to assess BBB inflammation/permeability. Body weight (bw) loss and the Garcia Neurological Test (GNT: motor, sensory, reflex, balance) served as surrogates of clinical recovery.

Figure 1



Results: Both ATIII and ENX similarly reduced *in vivo* penumbral LEU rolling and adhesion (Figure.1, $p < 0.05$). ATIII also reduced live BBB leakage (Figure.2, $p < 0.05$). ATIII animals demonstrated the least 48-hour bw loss ($8.4 \pm 1\%$) vs CCI+VEH ($11.4 \pm 0.5\%$, $p < 0.01$). GNT scores were similar among groups.

Figure 2



Conclusions: ATIII reduces post-TBI penumbral EC-LEU interactions in the BBB leading to reduced neuro-microvascular permeability. ATIII further reduced body weight loss compared to heparinoid or no therapy. Further study is needed to determine if these ATIII effects on neuroinflammation affect longer term neurocognitive recovery after TBI.

THE EXPRESSION OF REPULSIVE GUIDANCE MOLECULE A (RGMA) AFTER TRAUMATIC BRAIN INJURY: THE TIME-COURSE GENE EXPRESSION CHANGES IN THE MURINE CONTROLLED CORTICAL IMPACT MODEL

Eri Uemura MD, Goro Tajima MD, PhD, Naoya Matsumoto MD, PhD, Ayako Tokunaga PhD, Miyuki Miura, Takehiko Murase MD, PhD, Kazuya Ikematsu MD, PhD, Osamu Tasaki MD, PhD
Nagasaki University Hospital Acute & Critical Care Center

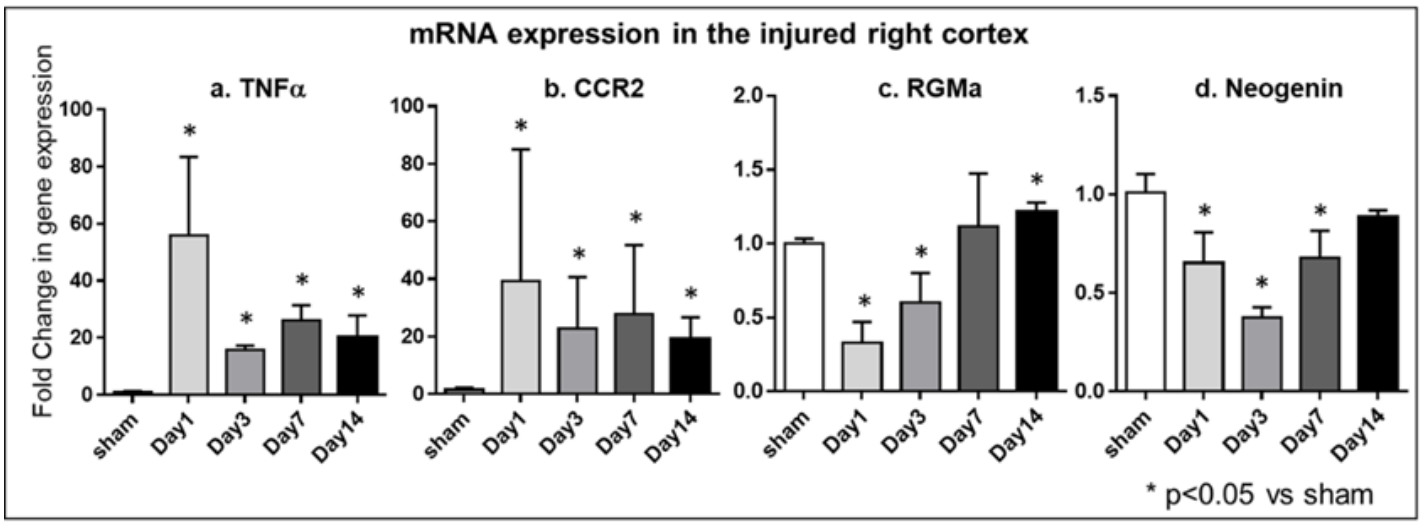
Invited Discussant: Eric Ley, MD

Introduction: Repulsive guidance molecule a (RGMa) is a key protein to regulate nerve regeneration negatively, as its inhibition enhances axonal growth and promotes functional recovery in spinal cord injury animal models. However, the role of RGMa in traumatic brain injury (TBI) remains elusive. The purpose of this study is to clarify TBI-responsive RGMa expression in a murine model.

Methods: Adult male C57Bl/6J mice were subjected to controlled cortical impact (CCI). Brains were extracted 1, 3, 7, and 14 days after the injury (n=6 in each group). Changes in the mRNA expression of RGMa and its receptor, Neogenin were evaluated by quantitative polymerase chain reaction (qPCR) in the damaged area of cortex, along with expression measurement of inflammation-related molecules. Neurological deficit was also assessed by the cylinder test in each time point.

Results: Neurological score was consistently lower in the CCI group compared to the sham group through the experimental period. mRNA expressions of representative inflammatory cytokine (TNF-a) and chemokine (CCR2) were remarkably increased at day 1 and gradually decreased over time, although kept higher values at least until day 14 (Figure a,b). mRNA expressions of RGMa and Neogenin were significantly suppressed in the damaged cortex until day 3. Interestingly, RGMa expression was suppressed most at day 1 and up-regulated over time, and significantly higher than the sham group at day 14 (Figure c,d)

Conclusion: In acute phase of TBI, significant inflammation was induced in the damaged cortex, and the expressions of RGMa and Neogenin were significantly decreased under inflammatory milieu of the damaged area. Contrary to the subsequent inflammatory remission, RGMa expression exceeded more than normal level two weeks after TBI. Intrinsic regenerative response to acute brain injury might be hampered by following up-regulation of RGMa, hinting the possibility of functional RGMa inhibition as a new effective maneuver against TBI.



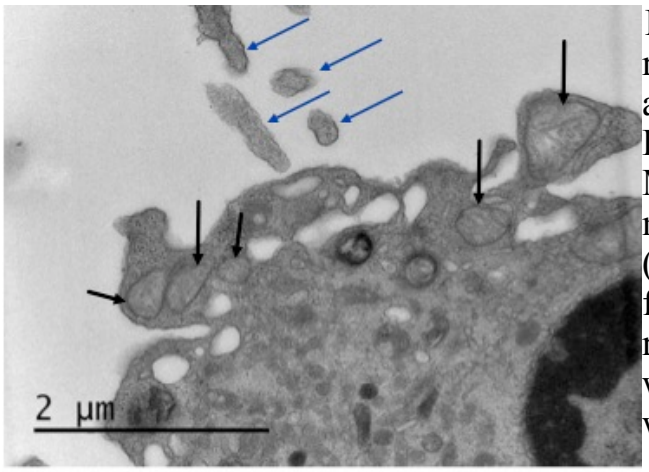
Session II: Plenary Papers 10-13
Paper 12: 1:40 PM - 2:00 PM

ACTIVE MONOCYTE EXOCYTOSIS OF MITOCHONDRIAL DAMPS SUPPRESSES NEUTROPHIL FUNCTION

Barbora Konecna PhD, Woon-Yong Kwon MD,PhD, Barbora Vlkova PhD, Quanzhi Zhang MSc, Jinbong Park PhD, Wei Huang PhD, Hyo In Kim MSc, Kiyoshi Itagaki PhD, **Carl J. Hauser MD**
BIDMC Medical Center

Invited Discussant: Raul Coimbra, MD, PhD

INTRODUCTION: Both trauma and primary infections increase risk of secondary infections. Injury mobilizes danger-associated molecular patterns (DAMPs) in the form of mitochondria (mt) released by cellular necrosis. It is unknown whether infection or other forms of inflammation might act similarly and how the release of mtDAMPs in such cases might predispose to secondary infection.



METHODS: Mitochondrial DNA (mtDNA) release from human monocytes (Mo) was studied after LPS stimulation using PCR (for Cytochrome B), fluorescent video-microscopy of live adherent Mo (using Mito-Tracker dye), electron microscopy and size exclusion chromatography (SEC). Human neutrophil (PMN) chemotaxis to fMLF (CTX, assayed in transwells) and respiratory burst (RB, assayed by luminometry) were studied after PMN incubation with or without mtDNA.

RESULTS: LPS exposure causes Mo to actively release mtDAMPS by the cells budding mt (Figure, black arrows). This occured mostly in the form of microvesicles (Figure, blue arrows) and to a lesser extent as exosomes (shown by PCR of the SEC exosome band). In the PMN studies, pre-incubation with mtDNA suppressed CTX to fMLF in a dose dependent manner ($P < 0.01$). CTX suppression by mtDNA was reversed by chloroquine (CQ) indicating an endosomal, TLR-9 dependent mechanism. In contrast, PMN RB was completely unaffected by mtDNA

CONCLUSIONS: In addition to the now well-known direct release of mtDAMPs by traumatic cellular disruption, inflammatory and or infectious stimuli appear able to cause active mtDAMP release in microvesicles. The mtDAMPs thus released appear to have unique effects on PMN functions that can contribute to the suppression of antimicrobial function. This DAMP-mediated "feed-forward" mechanism of amplifying innate immune responses might be generalizable to many forms of inflammation. And where it causes immune dysfunction that effect can be mitigated if the cellular pathways by which the DAMPs act can be defined. In this case, the endosomal inhibitor CQ is benign and well tolerated. So it might warrant study as a prophylactic anti-infective after mtDNA mobilization by injury or prior infection.

FREEZE DRIED PLATELETS REPAIR AND STABILIZE THE VASCULAR ENDOTHELIUM IN HEMORRHAGIC SHOCK

Shibani Pati MD, PhD, Daniel Potter PhD, Alpa Mahuvakar PhD, Byron Miyazawa BS, Martin Schreiber MD
University of California San Francisco

Invited Discussant: Ernest Moore, MD

Introduction: Currently in blood-banking practice in the US, platelets are stored in incubators at 22°C, with gentle agitation for up to 5 days. This short storage time has led to a global shortage of platelets for bleeding patients. A freeze-dried platelet-derived product (FDPlts) can circumvent these challenges by providing hemostasis, prolonging the shelf life of platelet products, improving safety from infectious risks, and significantly enhancing utilization (i.e. in remote and austere regions). In this study we aimed to test a human freeze dried platelet product in a murine model of hemorrhagic shock (HS) and trauma. FDPlts have been demonstrated to have potent hemostatic properties, but the vascular and organo-protective effects of the FDPlts remain to be elucidated. We hypothesized that FDPlts would have the capacity to regulate vascular stability and also function to mitigate organ failure induced by HS and trauma.

Methods: FDPlts were obtained from Cellphire Inc (Rockville, MD). *In vitro*, endothelial impedance (ECIS) assays were conducted with pulmonary endothelial cell (PECs) monolayers treated with FDPlts to determine if FDPlts could attenuate PEC permeability induced by thrombin. *In vivo*, a Miles assay of permeability was conducted to determine if intravenous (IV) FDPlts could attenuate vascular leak induced by VEGF-A. In a clinically relevant model of HS and trauma, IV FDPlts were tested to determine if FDPlts could attenuate pulmonary vascular leak and lung injury induced by HS. Scanning electron microscopy was utilized to evaluate FDPlt morphology and intravital microscopy determined if FDPlts could contribute to clot formation in injured vessels.

Results: Endothelial impedance assays demonstrate that FDPlts attenuate PEC permeability *in vitro* in a dose dependent fashion. In the Miles assay in mice, IV FDPlts inhibit vascular permeability induced by VEGF-A. In an established model of mouse HS and trauma, IV FDPlts administered after the shock period significantly attenuated pulmonary vascular permeability and lung injury comparable to whole blood resuscitation (Figure 1). Scanning electron microscopy reveals that FDPlts are comparable in morphology to 22°C activated platelets. Intravital microscopy of FITC-tagged FDPlts demonstrates that FDPlts adhere *in vivo* to injured vascular endothelium and contributes to clot formation.

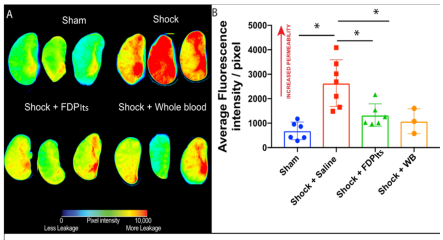


Figure 1. FDPlts attenuate pulmonary vascular permeability. **A)** Representative scans of lungs from mice infused with 10kD Dextran dyes. **B)** Quantitation of the average fluorescence intensity of the lungs which shows that FDPlts and whole blood transfusion block leak * = $p < 0.05$ via one way ANOVA tukey test. No significant difference was found between whole blood and FDPlts.

Conclusion: Our findings demonstrate that FDPlts have the capacity to attenuate vascular permeability and can contribute to clot formation suggesting that they may be a logistically superior option for use in bleeding patients. This is the first study to demonstrate that a platelet product can improve trauma associated organ failure and suggests that platelets could be beneficial in treating diseases characterized by vascular leak such as ARDS.

ASSOCIATION OF TIMING OF INITIATION OF PHARMACOLOGIC VENOUS THROMBOEMBOLISM PROPHYLAXIS WITH OUTCOMES IN TRAUMA PATIENTS

Jason Hecht, Emily Han Other, Mark R. Hemmila MD, Anne Cain-Nielsen, Wendy L. Wahl MD
St. Joseph Mercy Ann Arbor

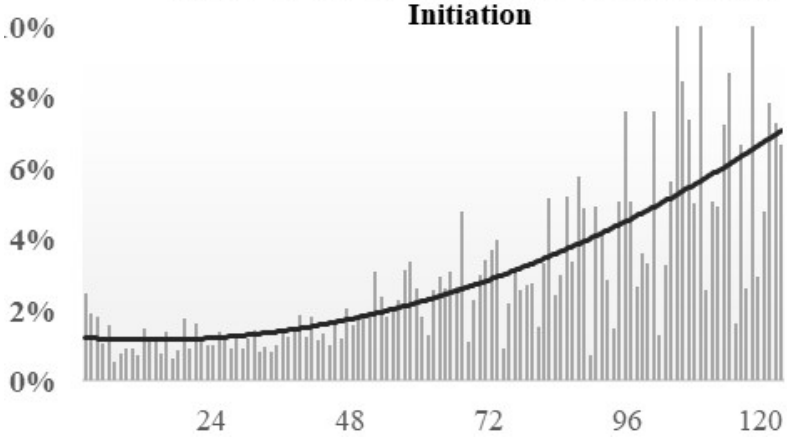
Invited Discussant: Elliott Haut, MD, PhD

Introduction: Venous thromboembolism (VTE) is a serious complication for trauma patients associated with significant morbidity and mortality. Current guidelines emphasize the importance of VTE chemoprophylaxis, however, the timing of initiation must balance the risks of thrombosis versus bleeding. Our study aims to address this literature gap by looking at the timing of chemoprophylaxis in all trauma patients.

Methods: Trauma quality collaborative data (2008-2019) was analyzed. Patients were excluded if hospitalization < 48 hours or no prophylaxis given. Comparison groups were based on timing of initiation of prophylaxis (< 24 hours, 24 to 48 hours, ≥ 48 hours). Risk-adjusted rates of mortality and VTE were calculated using patient factors including type of pharmacologic agent in addition to standard trauma patient confounders.

Results: Of the 89,165 patients analyzed, 1,752 (1.9%) died and 1.8% experienced a VTE complication. (**Figure 1**) After adjusting for type of prophylaxis and patient factors, delay in initiation of chemoprophylaxis to 24 – 48 or ≥ 48 hours after hospital presentation was associated with increased risk of VTE events (**Table 1**). These findings remained significant after exclusion of perceived higher-risk patients in sensitivity analysis. Delay in initiation of chemoprophylaxis in the ≥ 48 hour group also resulted in increased mortality as compared to earlier initiation.

Figure 1. VTE Rate by Hour of Prophylaxis Initiation



Conclusion: Early initiation of pharmacologic VTE prophylaxis in stable trauma patients reduces mortality and thrombotic complication.

Table 1. Risk of Mortality and VTE Stratified by Chemoprophylaxis Timing

	Timing of VTE Prophylaxis Initiation					
Outcome	0 to <24 hrs from Admission		24 to < 48 hrs from Admission		≥ 48 hrs from Admission	
Patients, n	42,780		27,323		19,062	
Mortality, % (n)	1.43 (610)		1.48 (404)		3.87 (738)	
Venous Thromboembolism, % (n)	1.06 (453)		1.33 (364)		4.20 (801)	
Risk Adjusted Outcome	OR (95% CI)	*p*-value	OR (95% CI)	*p*-value	OR (95% CI)	*p*-value
Mortality	Ref	--	0.87 (0.76-1.00)	0.053	1.16 (1.02-1.33)	0.026
Venous Thromboembolism	Ref	--	1.22 (1.06-1.41)	0.006	2.27 (1.98-2.60)	<0.001

RISK OF THROMBOEMBOLIC EVENTS AFTER THE USE OF TXA IN TRAUMA PATIENTS

Marianna Fischmann MD, Matthew Hernandez MD, Michael Traynor MD,
Martin D. Zielinski MD, Brian D. Kim MD
Mayo Clinic

Invited Discussant: Michelle McNutt, MD

Introduction: Administration of tranexamic acid (TXA) has been shown to reduce mortality after injury. Despite this benefit, TXA has been associated with arterial and venous thromboembolism in traumatically injured patients. The aim of this study was to describe thrombotic events in a rural community served by a Level I trauma center in patients administered TXA. We hypothesized that patients who received TXA would demonstrate higher rates of thrombotic events compared to those that did not.

Methods: This is a retrospective cohort study of trauma patients who received TXA (bolus or bolus and infusion) from January 2012 to January 2019. Demographics, mechanism of injury, hospital length of stay, and Injury Severity Score (ISS) were abstracted. The primary outcome was the frequency of thromboembolic events (up to 28 days after injury). Secondary outcome included in-hospital mortality. Univariate comparisons between those who received TXA versus those who did not after matching for mechanism of injury, age, sex, and ISS were performed. A subgroup analysis was performed looking at the outcomes for patients who received initial TXA bolus alone vs. bolus followed by maintenance infusion. A multivariable logistic regression analysis controlled for possible confounders, chosen based on the univariate analysis (massive blood transfusion activations, solid organ injuries, and blunt carotid injuries).

Results: A total of 848 patients were included, of whom 212 received TXA and 636 were in the matched control group. Overall, the median age was 48 years (IQR 28, 66) and 70.8% were male. There were no statistically significant differences between groups for age, sex and mechanism of injury. The median ISS was 26 (IQR 16, 34) in patients who were administered TXA and 22 (IQR 14, 29) in those who didn't (p=0.001). The rate of any thromboembolic event within 28 days was 12.7% (n=28) in the TXA group vs. 5.9% (n=38) in the control group (p=0.0007). The rate of DVT was 8.5% (n=18) vs. 3.5% (n=22) (p=0.0028). Pulmonary embolism was diagnosed in 3.8% (n=8) vs. 1.9% (n=12) (p=0.11). The rate of myocardial infarction was 1.9% (n=4) vs. 0.4% (n=3) (p=0.07). Stroke occurred in 2.4% (n=5) vs. 1.1% (n=7) in the control group (p = 0.18). The in-hospital mortality was higher in the TXA group (n=44, 20.8%) than in controls (n=64, 10%) ($p < 0.0001$). In multivariable analysis, patients who received TXA had increased odds of developing any thromboembolic event (OR 2.29 [95% CI 1.31-4.02], p=0.0037). The difference in mortality did not remain significant after adjustment (OR 1.19 [95% CI 0.73-1.93], p= 0.48). In a subgroup analysis, patients who received the initial bolus dose of TXA and a maintenance infusion had higher rates of thromboembolic events (24/106, 22.6%) than patients who received only the initial bolus (11/106, 10.4%), $p < 0.0001$.

Conclusion: In this observational study at a Level I Trauma Center, patients who received TXA had higher rates of thromboembolic events than matched controls. The administration of TXA for traumatically injured patients in the community setting should not be routine considering our results.

HEAD IN THE SAND? THE VALUE OF ROUTINE DUPLEX ULTRASOUND SCREENING FOR VENOUS THROMBOEMBOLISM IN THE TRAUMA PATIENT: A RANDOMIZED VANGUARD TRIAL

Sarah Majercik MD, **Annika Kay**, David Morris MD, Thomas White MD, Don VanBoerum MD, David Collingridge MSc, Joseph Bledsoe MD, Scott Stevens MD, Scott Woller MD
Intermountain Medical Center

Invited Discussant: M. Margaret Knudson, MD

Introduction: Venous thromboembolism (VTE) is a source of significant morbidity and mortality in injured patients. Current ACCP guidelines recommendation against routine duplex ultrasound (DUS) screening for deep vein thrombosis (DVT) but do not differentiatehigh-risk trauma patients from lower risk patients. Theevidence supporting this guideline is poor and mostly retrospective in nature. We hypothesized that moderate and high-risk trauma patients who undergo scheduled ultrasound surveillance for lower DVT will have a lower rate of symptomatic DVT, DVT propagation, and symptomatic or fatal pulmonary embolism (PE) than those who do not undergo screening.

Methods: Prospective, randomized vanguard trial between March 2017 and September 2019 of patients admitted to the Trauma service at a single, Level 1 trauma center, with a RAP score of 5 or greater. Patients were randomized to receive bilateral lower extremity DUS surveillance at days 1,3,7, and weekly thereafter during hospitalization versus no routine surveillance (testing for DVT could occur if clinically suspected). The two groups were compared with regard to DVT (distal and proximal lower extremity) and PE rates (both during the index hospitalization and at 90 days post-discharge),DVT propagation to popliteal vein or higher, major bleeding episodes, composite VTE/bleeding outcome, and all cause 90 day mortality. All patients received VTE chemoprophylaxis and treatment (if necessary) as per institutional protocols.

Results: 3236 trauma service admissions were screened. 1989 moderately high-risk (RAP>=5) patients were randomized (995 DUS group, 994 non-DUS). Patients had a mean age of 62 years, ISS of 14, RAP of 7.7, and 97% sustained blunt trauma. There was no difference between the groups with regard to age, gender, BMI, injury mechanism, RAP score, ISS, hospital or ICU LOS. DUS patients had a higher overall rate of DVT (15.1% vs. 1.7%, $p<0.001$), as expected. Most (87%) of the DVT in the DUS group were below the knee. Rate of proximal DVT was also higher in the DUS group (1.9% vs. 0.4% $p=0.003$). At 90 days, there were a total of 13 PE in the no DUS group vs. 7 in the DUS group, $P=0.26$. Overall mortality was not different between groups.

Conclusion: Routine surveillance DUS in high risk trauma patients diagnoses more DVT, most of which are below the knee. Routine surveillance does identify more proximal DVT than clinical suspicion alone, but does not result in less PE or death. Further studies are needed to delineate which sub-populations may benefit most from routine DUS surveillance.

Session III: Plenary Papers 14-18
Paper 17: 4:00 PM - 4:20 PM

HYBRID EMERGENCY ROOM SHOWS THE MAXIMUM EFFECT ON TRAUMA RESUSCITATION WHEN USED IN PATIENTS WITH HIGHER SEVERITY

Yutaka Umemura MD, PhD, **Natsuhiro Morita MD,** Kazuma Yamakawa MD, PhD, Hiroshi Ogura MD, Atsushi Watanabe MD, Satoshi Fujimi MD, PhD, Takahiro Kinoshita MD
Osaka General Medical Center

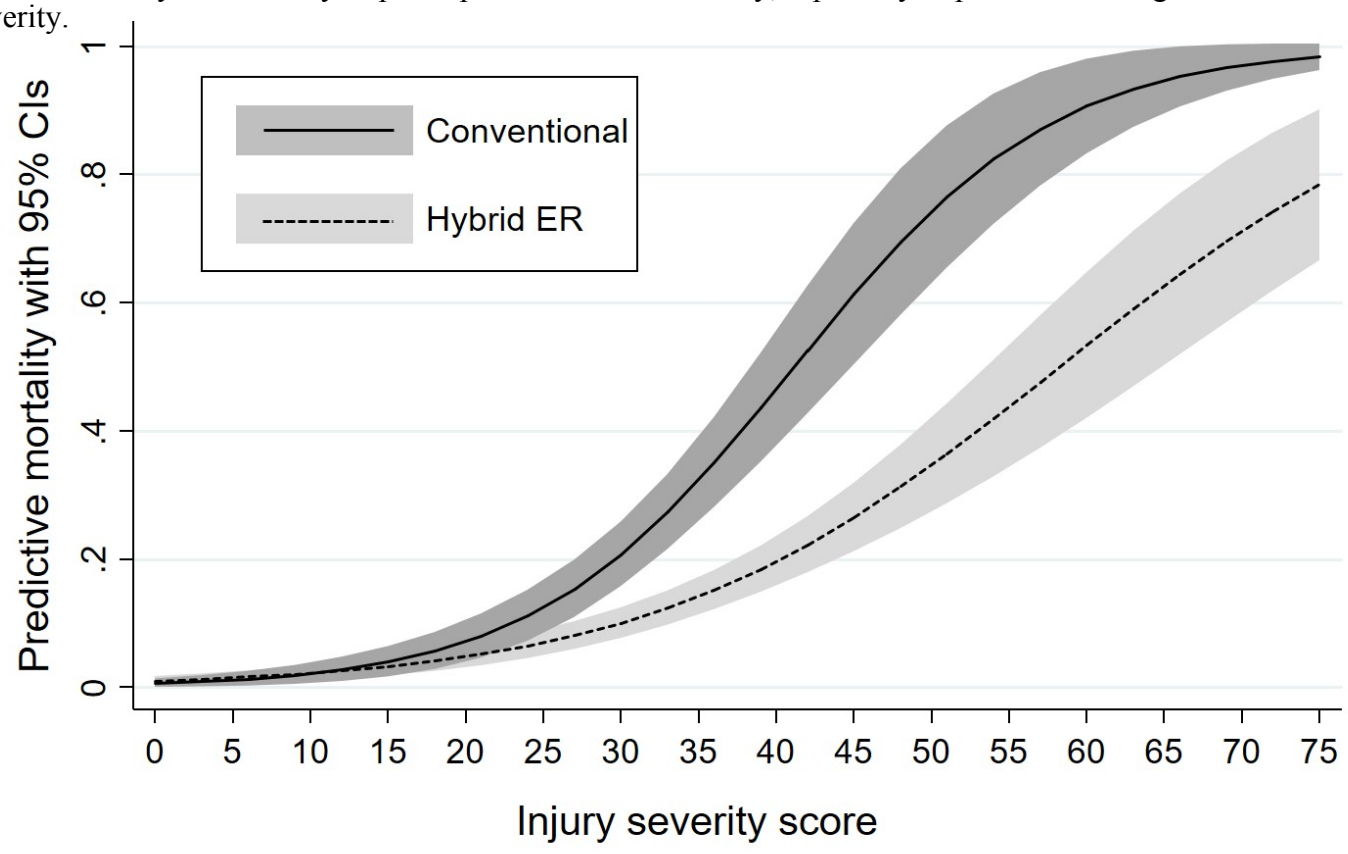
Invited Discussant: Laura Moore, MD

Background: Hybrid emergency room (ER) system is a novel trauma workflow which uses angio-computed tomography (CT) equipment in a trauma resuscitation room. In August 2011, we installed the world's first Hybrid ER in our hospital, and started to perform all examinations and treatments for trauma resuscitation in one room. However, effects of Hybrid ER has not been extensively investigated.

Material and Methods: This investigation was a retrospective cohort study conducted in a tertiary hospital in Japan from August 2007 to January 2020. We aimed to investigate survival benefit of the Hybrid ER and identify an optimal subset of trauma patients likely to receive higher benefits from the Hybrid ER. We consecutively included severe blunt adult trauma patients [Injury Severity Score (ISS) ≥16]. We divided study population into two groups: 1) the Conventional group (from August 2007 to July 2011) and 2) the Hybrid ER (from August 2011 to January 2020) group. We evaluated the association between 28-day mortality and the installation of Hybrid ER using multivariable logistic regression analysis. A restricted cubic spline analysis was conducted to evaluate the trend of 28-day mortality during the study period. To evaluate difference in effects on survival benefit based on patient severity, we also evaluated whether the effect of the Hybrid ER on survival was modified by patients' ISS.

Results: Among 1,050 trauma patients, 348 were in the Conventional group and 702 were in the Hybrid ER group. There was no significant difference in ISS and probability of survival (Ps) between two groups. We observed a significantly lower 28-day mortality in the Hybrid ER group (Ps adjusted odds ratio, 0.48; 95% confidence interval, 0.32–0.71; $P < 0.001$). Restricted cubic spline analysis revealed that thePs adjusted 28-day mortality sharply decreased approximately 200 days after the installation of the Hybrid ER. Increase of survival probabilities according to the increase of ISS was significantly curbed in Hybrid ER group (p for interaction = 0.014, Figure). As ISS increased over the level of 25, survival probabilities in Hybrid ER group was much lower compared to those in conventional group.

Conclusion: Hybrid ER may improve post-traumatic mortality, especially in patients with higher baseline severity.



Session III: Plenary Papers 14-18
Paper 18: 4:20 PM - 4:40 PM

REAL-TIME BEDSIDE MANAGEMENT AND TITRATION OF PARTIAL REBOA WITHOUT AN ARTERIAL LINE: GOOD FOR PRESSURE, NOT FOR FLOW!

Matthew Carr MD, Derek Benham MD, Richard Calvo PhD, Lyndsey Wessels MD, Joseph Lee BS, Andrew Schrader, Michael Krzyzaniak MD, Matthew Martin MD
Naval Medical Center San Diego

Invited Discussant: Megan Brenner, MD, MSc

Introduction: Partial resuscitative endovascular balloon occlusion of the aorta (pREBOA) attempts to minimize ischemia/reperfusion injury while still controlling hemorrhage. There is little data on optimal methods to evaluate and titrate partial flow, typically requiring invasive arterial line (AL) monitoring. We sought to examine the use of a miniaturized handheld digital pressure device (COMPASS) for pREBOA placement and titration of flow.

Methods: Ten swine underwent standardized hemorrhagic shock. Carotid and iliac pressures were monitored with both AL and COMPASS devices, and flow by aortic and SMA flow probes. pREBOA was inflated to control hemorrhage for 15 minutes before being deflated to try targeting aortic flow of 0.7L/min (using only the COMPASS device) by an operator blinded to the AL pressures and aortic flow. Correlations between COMPASS and proximal/distal AL were evaluated, as well as actual aortic flow.

Results: There was strong correlation between the distal MAP and the distal COMPASS MAP as seen in Figure 1 ($r=.979$, $p < 0.01$), as well as between the proximal AL and the proximal COMPASS on the pREBOA ($r=.989$, $p < 0.01$). There was a significant but weaker correlation between the distal compass MAP reading and aortic flow ($r=0.47$, $p < 0.0001$) though it was not clinically significant (Fig 2) and predicted flow was not achieved in a majority of the procedures. Of 10 pigs, survival times ranged from 10-120 minutes, with a mean survival of 50 minutes, and one pig surviving to 120 minutes.

Figure 1: Distal Arterial line MAP versus Distal COMPASS

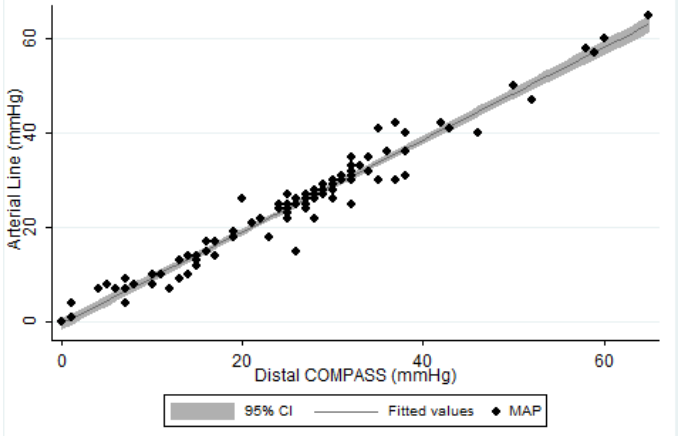
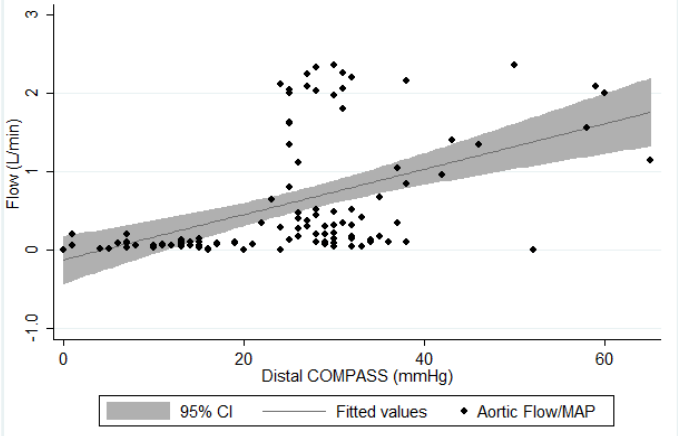


Figure 2: Aortic Flow versus Distal COMPASS MAP



Conclusion: Highly reliable pressure monitoring is achieved proximally and distally without arterial lines using the COMPASS device on the pREBOA. Despite accurate readings, distal MAPs were a poor indicator of aortic flow and titration based upon distal MAPs did not provide reliable results. Further investigation will be required to find a suitable proxy for targeting specific aortic flow levels using pREBOA.

GALL STONES RELATED COMPLICATIONS AFTER UNTREATED BILIARY COLIC: A SIX-MONTH READMISSIONS STUDY

Faisal Jehan MD, Jorge Con MD, Kartik Prabhakaran MD, Muhammad Khan MD, Muhammad Zeeshan MD, Peter Rhee MD, MPH, Rifat Latifi MD
New York Medical College -Westchester Medical Center

Invited Discussant: James Davis, MD

Introduction: Cholelithiasis and its subsequent complications are the leading causes of hospital admissions related to gastrointestinal problems. Cholecystectomy is considered the standard of care for the management of symptomatic cholelithiasis and biliary colic. The incidence of recurrence of symptoms and complications after an untreated biliary colic has never been studied. The aim of our study was to evaluate the incidence of complications after an untreated biliary colic.

Methods: We performed five years (2010-2014) analysis of the national readmission database and included all adult patients diagnosed with biliary colic or symptomatic cholelithiasis without cholecystitis, choledocholithiasis, cholangitis and pancreatitis who did not underwent cholecystectomy. Primary outcome measures were readmissions for biliary colic, acute cholecystitis, choledocolithiasis, cholangitis and pancreatitis within 3 months and 6 months.

Results: We included a total of 22,345 patients with the diagnosis of biliary colic. Mean age was 42±4 years and 64% were female. The incidence of a gallstone-related complication by 3-months and 6-months are 23% and 35% respectively. The incidence of recurrent biliary colic was 9%and 12%; acute cholecystitis 7% and 10%; choledocolithiasis 4% and 5%; cholangitis 1%and 2%; and pancreatitis 2% and 6% within 3 months and 6 months respectively.

Conclusion: Untreated biliary colic is associated with a very high rate of 3 months and 6 months gall-stones related complications. Cholecystitis should be performed as soon as possible after biliary colic to prevent these complications. Further studies exploring the reasons of delaying cholecystectomy in these patients are warranted.

BILE DUCT CLEARANCE AND CHOLECYSTECTOMY FOR CHOLEDOCOLITHIASIS: ONE - STAGE LAPAROSCOPIC CHOLECYSTECTOMY WITH INTRA-OPERATIVE ENDOCOPIC RETROGRADE CHOLANGIOPANCREATOGRAPHY (ERCP) PROCEDURE VERSUS TWO - STAGE PROCEDURE

Gary Bass MD, MBA, Arvid Pourlotfi MD, Mark Donelly MD, Caroline McIntyre MD, Rebecka Ahl MD, PhD, Yang Cao PhD, Babak Sarani MD, Amy Gillis MD, Shahin Mohseni MD, PhD
Orebro University Hospital

Invited Discussant: Caroline Reinke, MD

Introduction: Significant clinical equipoise exists regarding optimal sequencing in the definitive management of choledocholithiasis. Central to this is the migration in treatment algorithm from sequential biliary ductal clearance and gallstone reservoir management (either at index admission or at an interval) to simultaneous laparoendoscopic management. Our current study compares these two different approaches.

Methods: Patients were recruited from a Swedish and an Irish university hospital with different practice patterns for definitive management of choledocholithiasis. In the former, patients with choledocholithiasis undergo one-stage procedure with laparoscopic cholecystectomy with intra-operative rendezvous ERCP at index admission, while in the latter, patients undergo endoscopic biliary duct clearance on index admission and return following recovery for interval day-case laparoscopic cholecystectomy (two-stage procedure). Demographics, clinical characteristics, and outcomes were compared between these approaches over the period January 2015-December 2018. Outcomes of interest were post-procedural complications and total hospital days.

Results: Three hundred fifty seven consecutive patients were treated for choledocholithiasis during the study period, of these, 222(62.2%) patients underwent one-stage procedure, while 135(37.8%) underwent two-stage procedure. Patients in both cohorts were closely matched in terms of age, sex and serum peak total bilirubin. Patients in the one-stage procedure group exhibited a greater inflammatory reaction as measured by their C-reactive protein (136±137 vs. 95±102mg/L, $p=0.024$), and had higher rate of co-morbidities (Charlson Comorbidity Index ≥3: 37.8% vs 20.0%, $p=0.003$), and were less fit for surgery (ASA ≥3: 11.7% vs. 3.7%,$p < 0.001$). A significantly shorter mean time to definitive treatment, i.e. cholecystectomy (3.1±2.5 vs 40.3±127 days, $p=0.017$), without any excess morbidity, was detected in the one-stage compared to two-stage cohort. Patients in the one-stage cohort experienced shorter mean post-procedure length of stay (3.0±4.7 vs 5.0±4.6 days, $p < 0.001$) and total length of hospital stay (6.5±4.6 vs 9.0±7.3 days, $p=0.002$).

Conclusion: Within the context of developing European and US models of Acute Care Surgery, consideration should be given to index-admission laparoscopic cholecystectomy with intra-operative ERCP for treatment of choledocholithiasis. Our data suggest this strategy significantly shortens time to definitive treatment, decreases total hospital stay without any excess in adverse outcomes, reduces the financial burden on the healthcare system, and could potentially increase patient satisfaction.

EVALUATING THE ASSOCIATION BETWEEN AAST EMERGENCY GENERAL SURGERY SEVERITY GRADES AND OUTCOMES USING NATIONAL CLAIMS DATA

John W. Scott MD, MPH, Kristan L. Staudenmayer MD, MSc, Garth H. Utter MD, MSc
Department of Surgery, University of Michigan

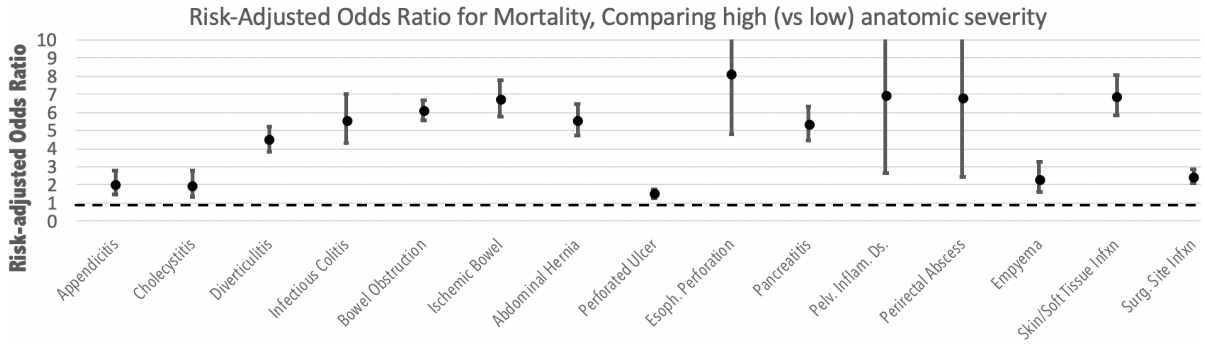
Invited Discussant: Heena Santry, MD

Background: Emergency General Surgery (EGS) encompasses a heterogenous population of acutely ill patients, and standardized methods for determining disease severity are essential for comparative effectiveness research and quality improvement initiatives for EGS. The AAST Patient Assessment Committee has developed a 5-level grading system for the anatomic severity of 16 EGS conditions; however, little is known regarding how well these AAST EGS grades can be approximated by diagnosis codes used in administrative databases.

Methods: We identified all adult hospitalizations in the 2012-2017 Nationwide Inpatient Sample that had a principal diagnosis of one of the 16 EGS conditions using ICD-9-CM (2012-2015q3) and ICD-10-CM (2015q4-2017) diagnosis codes. We assigned AAST clinically-derived anatomic severity grades using the principal diagnosis, as well as secondary diagnoses that assist in assigning disease severity. We evaluated whether assigned EGS grades (2-4 categories, or dichotomized into less vs. more severe) were associated with clinical outcomes, including in-hospital mortality, complications, length of stay (LOS), and adjusted hospital costs. We hypothesized that ICD codes could distinguish EGS condition severity, as determined by association with worse outcomes. Analyses were adjusted for age, sex, Charlson comorbidity index, US Census division, and year.

Results: The weighted sample of EGS patients included 11,644,457 adults from 2012 to 2017. ICD-9-CM and ICD-10-CM mapping were similar in how many distinct clinical strata could be assigned. The number of strata per condition for ICD-9-CM was 2 (6 conditions), 3 (6 conditions), and 4 strata (4 conditions). ICD-10-CM mapped to 2 (8 conditions) 3 (6 conditions), and 4 strata (2 conditions). Higher severity strata (vs. the lowest) were associated with higher risk-adjusted odds of mortality in all conditions except breast abscess (no deaths) and PID. Higher strata were associated with complications in all conditions except PID. LOS and costs were significantly greater in higher strata for all conditions. Across each of the 16 conditions, there was a significant association between higher dichotomized severity and each of the four outcomes (mortality shown in Figure).

Conclusion: The AAST EGS anatomic disease severity grades approximated from ICD-9/-10-CM diagnosis codes demonstrate good construct validity and offer a viable alternative to determining EGS grades by medical record review. Future work is needed to validate against prospectively collected clinical data. EGS grades approximated from claims data may be useful in EGS benchmarking and quality improvement efforts.



Session IV: Plenary Papers 19-22
Paper 22: 10:00 AM - 10:20 AM

READMISSION FOR VENOUS THROMBOEMBOLISM AFTER EMERGENCY GENERAL SURGERY IS UNDERREPORTED AND INFLUENCED BY INSURANCE STATUS

Rishi Rattan MD, Alessia Cioci MD, Eva Urrechaga MD, Matthew Chatoor MD, Joseph Krocker MD, Deanna Johnson, Gary Curcio MD, Nicholas Namias MD, MBA, Daniel D. Yeh MD, Enrique Ginzburg MD, Joshua Parreco MD
University of Miami

Invited Discussant: Myung Park, MD

Introduction: Prior studies of venous thromboembolism (VTE) after emergency general surgery (EGS) have been limited to single institutions or are not nationally representative. However, up to 1 in 3 postoperative readmissions occur at another hospital and are not captured by current metrics. We hypothesized that different-hospital readmission accounted for a significant number of readmissions with VTE after EGS and that predictive factors would be different for same- and different-hospital readmissions.

Methods: The 2010-2014 Nationwide Readmissions Database (NRD) was queried for all non-elective, short-stay (< 4 days) EGS hospitalizations. EGS was determined using the American Association for the Surgery of Trauma Committee on Severity Assessment and Patient Outcomes definition, comprised of diagnosis and procedures codes from the 9th edition of the International Classification of Diseases. The primary outcome was readmission within 180 days with VTE. The secondary outcome was readmission to a different hospital within 180 days with VTE. Univariate analysis of the NRD's 47 demographic, clinical, and hospital variables with exploratory $p < 0.1$ identified variables to include in multivariate logistic regressions. These analyses identified risk factors, reported as odds ratios with their 95%confidence intervals, for readmission to index and different hospitals with VTE, with significance set at $p < 0.05$. Patients were excluded if during the index admission they: expired, developed a VTE, had a vena cava filter placed, or did not have at least 180 days of follow up. Results were weighted for national averages according to Healthcare Utilization Project guidelines.

Results: Of 1,160,694 patients meeting inclusion criteria, 5,404 (0.5%) patients were readmitted within 180 days with a VTE. Of these, 1,568 (29%) were readmitted to a different hospital. The strongest predictors overall for readmission with VTE were tracheopulmonary surgery and metastatic cancer. However, the strongest predictors for readmission to a *different* hospital were small index hospital and Medicaid as the payor (Table).

Risk factors for readmission within 180 days with VTE, OR (95% CI)

Age ≥ 65 years	CCI ≥ 2	Obesity	Metastatic cancer	Medicare	Type of surgery	
					Soft tissue	Tracheo-pulmonary
2.09 (1.87-2.34)	2.03 (1.88-2.20)	1.39 (1.29-1.50)	2.58 (2.31-2.87)	1.26 (1.15-1.37)	1.96 (1.72-2.23)	3.50 (3.08-3.96)

Risk factors for different hospital readmission within 180 days with VTE, OR (95% CI)

Diabetes	Medicare	Medicaid	For-profit hospital	Hospital size		Non-appendix GI surgery
				Small	Medium	
1.22 (1.04-1.43)	1.25 (1.07-1.45)	1.48 (1.19-1.84)	1.25 (1.06-1.48)	1.64 (1.36-1.98)	1.24 (1.06-1.44)	1.37 (1.07-1.77)

VTE, venous thromboembolism. CCI, Charlson Comorbidity Index. GI, gastrointestinal.

Conclusions: 1 in 3 readmissions with VTE after EGS occur at a different hospital and may be missed by current quality metrics that only capture same-hospital readmission. Such metrics may underestimate for-profit hospital postoperative VTE rates relative to public and non-profit hospitals, potentially affecting benchmarking and reimbursement. Fragmentation of care appears to be affected by insurance status in addition to clinical factors. These findings have implications for policy and prevention programming design. Further study is needed to better understand this significant and unique patient population.

UNIVERSAL SCREENING FOR BLUNT CEREBROVASCULAR INJURY

Jonathan A. Black MD, Russell Griffin PhD, Peter Abraham MD, Elizabeth Le MD, Bart Thaci MD, Mark Harrigan MD, Jeffrey D. Kerby MD, PhD, Jan O. Jansen MBBS
University of Alabama at Birmingham

Invited Discussant: Walter Biffl, MD

Introduction: Blunt cerebrovascular injury (BCVI) can cause thromboembolic stroke. Most trauma centers selectively screen patients with neck computed tomographic angiography (CTA) based on clinical criteria. The incidence of BCVI among blunt trauma admissions using selective screening protocols has been reported to be approximately 2-3%. However, approximately 20% of patients with BCVI lack specific screening criteria and are usually diagnosed only after developing neurological symptoms; as a result, the 20% is likely an underestimate of the true number of undiagnosed BCVIs. In 2016, our institution adopted universal BCVI screening in blunt trauma patients using a 64-slice neck CTA protocol that involved no additional IV contrast and only minimal additional radiation exposure. The aim of this study was to accurately determine the incidence of BCVI and evaluate the diagnostic performance of the Denver (DC), expanded Denver (eDC), and modified Memphis (mMC) criteria in selecting patients for screening.

Methods: Retrospective review of all neck CTAs obtained in blunt trauma patients over a two year period, from August 2017 to August 2019. Each neck CTA was individually reviewed to evaluate for the presence of BCVI. Patient records were also evaluated for objective injury criteria that would have triggered screening for BCVI based on the DC, eDC, and mMC.

Results: A total of 6800 patients who had suffered blunt trauma were evaluated, of whom 5634 (82.8%) had a neck CTA. The majority of patients who were not screened for BCVI had no head or neck injury (69%), were transfers from another facility (21%), or were not admitted to a trauma unit from the emergency department (5%). A total of 471 patients (8.4%) had CTA evidence of BCVI on admission. Table 1 shows the diagnostic performance of commonly used selective screening criteria compared to universal screening. The eDC identified the most BCVI cases (sensitivity=75%) but had the lowest accuracy (PPV=15.2%). The DC and mMC were slightly more accurate (PPV~20%) and had the highest diagnostic ability (LR+ 2.8 and 3.0, respectively), but had low sensitivity (57.7% and 47.6%, respectively). Consequently, if relying on traditional screening criteria, the DC, eDC, and mMC would have respectively resulted in 42.2%, 24.8%, and 52.4% of patients with BCVI identified by universal screening not receiving a neck CTA to screen for BCVI.

Conclusions: The true incidence of BCVI is greater than previously recognized. Commonly used screening criteria fail to detect a considerable number of BCVI cases. Consideration should be given to universal screening for BCVI using neck CTA in blunt trauma.

Table 1. Screening diagnostic measures of three commonly used criteria for blunt cerebrovascular injury

Diagnostic	Denver	Expanded Denver	Modified Memphis
% Total patients screening positive	23.9%	41.4%	18.7%
False negative rate	42.2%	24.8%	52.4%
False positive rate	20.9%	38.3%	16.1%
Sensitivity	57.7%	75.2%	47.6%
Specificity	79.1%	61.7%	83.9%
Positive Predictive Value	20.2%	15.2%	21.2%
Negative Predictive Value	95.4%	96.5%	94.6%
Likelihood Ratio Positive	2.8	2.0	3.0

THE IMPACT OF DELAYED HIP FRACTURE MANAGEMENT ON HEALTH OUTCOMES FOR AFRICAN AMERICAN OLDER ADULTS

Molly Jarman PhD, MPH, Claire Sokas MD, Michael K. Dalton MD, MPH, Tarsicio Uribe-Leitz MD, MPH, Manuel Castillo-Angeles MD, MPH, Marilyn Heng MD, Arvind von Keudell MD, Zara Cooper MD, MSc, Ali Salim MD
Brigham and Women's Hospital

Invited Discussant: Anne Mosenthal, MD

Introduction: Delays in surgical management of hip fractures are associated with worsened health outcomes for older adults. There is evidence that systematic delays in emergency medical care disadvantage African American patients seeking treatment for acute medical conditions (e.g. myocardial infarction), but similar patterns have not been examined in geriatric injury care. Our objectives were to 1) determine if delays in hip fracture management are more common for African American patients than White patients and 2) determine if delays in hip fracture management contribute to racial differences in health outcomes following hip fracture.

Methods: We identified adults age ≥65 with race categorized as White/Non-Hispanic or African American/Non-Hispanic and diagnoses consistent with isolated hip fracture in the 2007-2016 Trauma Quality Program Public Use File. We categorized hip fracture management as non-surgical, timely surgery (< 24 hours from arrival), and delayed surgery (> 24 hours from arrival), and used multivariable logistic regression models to estimate the associations between African American race, timeliness of surgical intervention, hospital length of stay, and health outcomes associated with prolonged immobility (catheter-associated urinary tract infection and decubitus ulcer), adjusting for age and sex. We then used binary mediation models to determine the proportion of excess complications for African American patients attributable to delayed hip fracture management.

Results: Of 126,314 eligible patients, 5% were African American, 67% were female, the median age was 80 (SD = 7), and average length of stay was 6.2 days (SD = 4.6). Compared to otherwise similar White patients, African Americans were 15% less likely to undergo surgical hip fracture repair (OR = 0.85, $p < 0.001$), 45% more likely to experience delayed surgery (OR = 1.45, $p < 0.001$), and experienced wait time to surgery that was 6.4 hours longer on average ($p < 0.001$). African Americans were more likely to experience catheter-associated urinary tract infection (OR = 1.27, $p < 0.001$) and decubitus ulcer (OR = 1.59, $p < 0.001$), and had an average length of stay that was 1.05 days longer ($p < 0.001$). In mediation models, 7.7% of excess urinary tract infections and 10.3% of excess decubitus ulcers experienced by African American patients were attributed to variation in timing of surgical hip fracture repair.

Conclusion: Delays in surgical hip fracture repair disproportionately impact African American older adults, contributing to increased risk of complications and longer hospital length of stay. Efforts to prepare the US trauma care system for the aging population must ensure equitable access to high quality trauma care and orthopaedic surgery for all communities.

A NATIONWIDE PROSPECTIVE MULTICENTER STUDY ON DEFINITIVE SURGERY FOR ISOLATED HIP FRACTURE WITHIN 24 HOURS

Darwin Ang, Mark G. McKenney MD, Patrick J. Offner MD, MPH, Stephen F. Flaherty MD, Matthew M. Carrick MD, David S. Plurad MD, Ernest A. Gonzalez MD, John H. Armstrong MD, Jeffrey Anglen MD, Roger Nagy MD, MIchele Ziglar, Huazhi Liu MSc, Greg McCormack BS, Julie Nash, Mary Danish BS
Ocala Regional Medical Center

Invited Discussant: Alicia Mangram, MD

Introduction: Isolated hip fractures (IHFs) are high frequency/high morbidity injuries. Definitive surgery < 24 hours from admission has been associated with improved mortality. An IHF practice management guideline (IHF-PMG) was developed for a large multi-hospital network to help achieve a goal of ≥ 70% definitive surgery < 24 hours. We report on its feasibility and results.

Methods: This is a prospective multicenter cohort study; involving 85 U.S. Trauma Centers. From 2017 to 2019, patients ≥ 65 years with IHF were included. Four cohorts were examined; 1) hospitals that used the network's IHF-PMG, 2) hospitals that used their own PMG, 3) hospitals that partially used the network IHF-PMG, and 4) hospitals that did not implement any PMG. The primary outcome was inpatient mortality. Multivariable regression with reliability adjustment was used to calculate the expected value for the mortality observed to expected ratio (O/E).

Results: Data on 29,920 IHFs were prospectively collected. After implementation of the IHF-PMG, IHF mortality decreased within the hospital network from 2017, 2018, and 2019 (2.6% vs. 1.6% vs. 1.5%, p - value = 0.04). This was observed even after risk adjustment, mortality (O / E) 1.08, 0.84, and 0.81, respectively. Hospitals that developed their own IHF-PMG or used the system's IHF-PMG had the lowest mortality at 1.2% and 1.4% vs. 1.7% and 2.0%, p-value = 0.02). Complication rates and hospital LOS were also lowest for both groups.

Conclusion: The goal directed IHF-PMG for definitive surgery within 24 hours was possible to implement across a large nationwide hospital network. The IHF-PMG was associated with lower inpatient mortality and hospital LOS.

Session V: Plenary Papers 23-29
Paper 26: 11:35 AM - 11:55 AM

A MULTICENTER TRIAL OF THE EVOLVING DIAGNOSIS AND MANAGEMENT OF HIGH-GRADE PANCREATIC INJURIES

Walter L. Biffl MD, Bryan C. Morse MD, Michelle K. McNutt MD, Jason S. Lees MD, Rishi Rattan MD, Miklosh Bala MD, Chance Spalding PhD, DO, S. Rob Todd MD, Rachael A. Callcut MD, Paul J. Chestovich MD, James W. Davis MD, Linda Dultz MD, Gregory J. Jurkovich MD, Michaela A. West MD, PhD, Ernest E. Moore MD
Scripps Memorial Hospital- La Jolla

Invited Discussant: Babak Sarani, MD

Introduction: Outcomes following pancreatic trauma have not improved significantly over the past two decades, in large part due to their infrequency and a dearth of data guiding management. In 2013 the Western Trauma Association published an algorithm for pancreatic trauma, highlighting emerging data that might change the approach to the diagnosis and management of high-grade pancreatic injuries (Grade III-V; HGPI). We hypothesized that the use of magnetic resonance cholangiopancreatography (MRCP), pancreatic duct stenting, operative drainage vs resection, and nonoperative management of HGPI have increased since the publication of the algorithm.

Methods: Multicenter retrospective review of diagnosis, management, and outcomes of adult pancreatic injuries from 2010-2018. Data were analyzed by grade and time period relative to algorithm publication (PRE, 2010-2013; POST, 2014-2018) using Chi-Square, Fisher's Exact, and Z-tests where appropriate.

Results: 32 centers reported complete data on 1081 patients. Of the 454 (42%) with HGPI, 233 (51%) had penetrating trauma and 61% went directly to the operating room (OR) without imaging. 67 (15%) died within 24 hrs (7% PRE vs 7% POST). Management and outcomes of 24-hr survivors are summarized in the Table. Proportions of resection: drainage changed among grade IV and V injuries ($p<.05$). Among patients who had the diagnosis of grade IV/V injury made by CT, there was an increasing trend to manage nonoperatively (10% PRE vs 21% POST, $p=.22$). Among all HGPI patients, MRCP (9% to 13%, $p=.20$) and ERCP (11% to 17%, $p=.12$) trended upward. Pancreatic duct stenting increased from 7% to 15% ($p=.016$) and indications for stents changed from primary/prophylactic (54% PRE) to managing complications (71% POST). CT scanning was diagnostic of main duct integrity in only 26%. Moreover, 41% of grade II injuries had complications, suggesting possible under-grading by imaging. Overall pancreas-related complications trended upward (30% PRE to 41% POST, $p=.07$).

	III PRE	III POST	IV PRE	IV POST	V PRE	V POST
24 hour survivors	113	185	15	42	11	21
Operative Resection	86 (76%)	149 (81%)	9 (60%)	20 (48%)	8 (73%)	12 (57%)
Operative Drainage	11 (10%)	24 (13%)	3 (20%)	15 (36%)	3 (27%)	7 (33%)
Operative Other/Neither	5 (4%)	4 (2%)	1 (7%)	2 (5%)	0	1 (5%)
Nonoperative	11 (10%)	8 (4%)	2 (13%)	5 (12%)	0	1 (5%)
MRCP	11 (10%)	21 (11%)	0	5 (12%)	1 (9%)	6 (29%)
ERCP	14 (12%)	25 (14%)	1 (7%)	11 (26%)	0	5 (24%)
Stent	9 (8%)	22 (12%)	1 (7%)	10 (24%)	0	4 (19%)
Mortality after 24 hr	9 (8%)	13 (7%)	1 (7%)	2 (5%)	1 (9%)	1 (5%)
Pancreatic Complication	36 (32%)	70 (38%)	6 (40%)	20 (48%)	4 (36%)	11 (52%)

Conclusion: The number of patients with HGPI at most trauma centers is low. Nearly half result from penetrating trauma and most are diagnosed and managed in the operating room. Resectional management of grade III injuries is the norm, but drainage of grade IV/V injuries is increasingly favored over resection. There are trends toward increasing use of MRCP, ERCP and nonoperative management in recent years but the numbers are small and there is no statistical difference. Early mortality is decreasing but complications remain problematic. Prospective studies should focus on accurate assessment of ductal integrity as well as prevention and treatment of pancreatic abscess and fistula.

Session V: Plenary Papers 23-29
Paper 27: 11:55 AM - 12:15 AM

HARD SIGNS GONE SOFT

Anna Romagnoli MD, Joseph J. DuBose MD, Anahita Dua MD, Richard Betzold, Tiffany K. Bee MD, Timothy C. Fabian MD, Jonathan Morrison MD, PhD, David V. Feliciano MD, David J. Skarupa MD, Jeanette Podbielski, Richard Catalano MD, Xian Luo-Owen PhD, Kenji Inaba MD, David S. Kauvar MD, MPH
Massachusetts General Hospital

Invited Discussant: Enrique Ginzburg, MD

Introduction: Clinical "hard signs" (HS) of vascular injury were described over 30 years ago and continue to be espoused as foundational tools in determining the need to proceed immediately to operation. We hypothesize that, in contemporary practice, HS no longer obviate the utilization of additional imaging prior to intervention.

Methods: The American Association for the Surgery of Trauma (AAST) PROspective Observational Vascular Injury Treatment (PROOVIT) registry was utilized to correlate the presence of HS in extremity vascular injury with subsequent diagnosis and management.

Results: Of 1910 cases, 1108 (58%) had one or more HS of vascular injury--82.6% of whom presented with active hemorrhage or expanding hematoma, 15.3% with only ischemia. Computed tomographic angiography (CTA) was performed in (26.6%) of cases (24% of hemorrhagic HS patients, 40% ischemic HS patients). Diagnosis of vascular injury was made by operative exploration without additional imaging in 65% of cases--70% of hemorrhagic HS patients, 45.3% ischemic HS patients, ($p<0.0001$).

In cases of exploration without imaging, open repair (OR) was performed in 68% of cases while endovascular or hybrid repair (EHR) was utilized in 1.4%. In all-comers with HS who underwent CTA, OR was performed in 63.9% of cases while EHR was utilized in 9.8% of cases ($p<0.0001$).

Hemorrhagic HS patients who underwent operative exploration without additional imaging had a 68.3% rate of OR and a 1.6% rate of EHR, compared with hemorrhagic HS patients who underwent CTA, who had a 61.8% rate of OR and a 10.5% EHR, $p<0.0001$. Ischemic HS patients who underwent operative exploration without additional imaging had a 76.6% rate of OR, and 0 reported EHR, compared with ischemic HS patients who underwent CTA had a 72.01% rate of OR and 5.9% rate of EHR ($p=0.0471$).

There was no difference in units of pRBCs transfused, in-hospital mortality, amputation or reintervention rate between the OR and EHR groups.

Conclusion: Classic teaching is that hard signs of vascular injury warrant open surgery with no further imaging. The inclusion of CTA in the workup of patients with HS of vascular injury resulted in a significant increase in endovascular or hybrid repair in patients with both hemorrhagic and ischemic hard signs, with no difference in outcomes. In contrast to traditional practices, patients with hard signs of vascular injury who are stable may benefit from the acquisition of additional information afforded by CTA which may facilitate alternate management strategies; further prospective study is required

Session V: Plenary Papers 23-29
Paper 28: 12:15 AM - 12:35 AM

PROSPECTIVE STUDY OF SHORT-TERM QUALITY OF LIFE AFTER TRAUMATIC RIB FRACTURES

Jeff Choi MD, Suleman Khan, Nicholas Hakes, Garrison Carlos MD, Joshua Jaramillo MD, Ryan Seltzer BS, David A. Spain MD
Stanford University

Invited Discussant: Suresh Agarwal, Jr., MD

Introduction: Comprehensive post-discharge quality of life (QoL) of patients who suffer traumatic rib fractures in the current era of multi-modality pain management remains unclear. We hypothesized that even isolated rib fractures confer considerable QoL burden, and that opportunities for intervention post-discharge may exist.

Methods: We prospectively enrolled adult patients at our Level I trauma center with rib fractures starting July 1, 2019. We excluded patients with baseline dementia or Glasgow Coma Scale < 15 at discharge. QoL was assessed at 1 and 3-months after discharge using the Trauma Quality-of-Life questionnaire (T-QoL; a comprehensive and sensitive QoL assessment tool for trauma patients) and 6 additional questions. Paired t-test compared differences in 1 vs 3-month responses. We performed a subgroup analysis on patients with isolated rib fractures.

Results: 120 patients (mean age 66.2 years, 38.5% female) have been enrolled to date, with 78.3% (94/120) and 74.7% (59/79) follow-up at 1 and 3 months, respectively. At 3 months after discharge, 31.0% of patients who were working prior to injury were not back at work, and 8.5% were still dependent on narcotic pain medications. Despite mild improvements compared to 1-month post-discharge, QoL remained suboptimal at 3 months post-discharge. Patients especially reported poor overall recovery (T-QoL mean±SD: 2.87±0.66) and physical well-being (T-QoL mean±SD: 2.91±0.79). The subgroup with isolated rib fractures reported similarly suboptimal QoL in the domains of recovery (T-QoL mean±SD: 3.06±0.61) and physical well-being (T-QoL mean±SD: 3.23±0.63) at 3 months post-discharge.

Conclusion: Traumatic rib fractures are associated with suboptimal QoL at 1 and 3 months after injury, placing patients at risk for post-traumatic stress disorder. Even after isolated rib fractures, patients reported poor physical well being and poor overall recovery. Longer-term follow-up and delayed interventions such as improved pain management or operative fixation may be warranted to improve QoL.

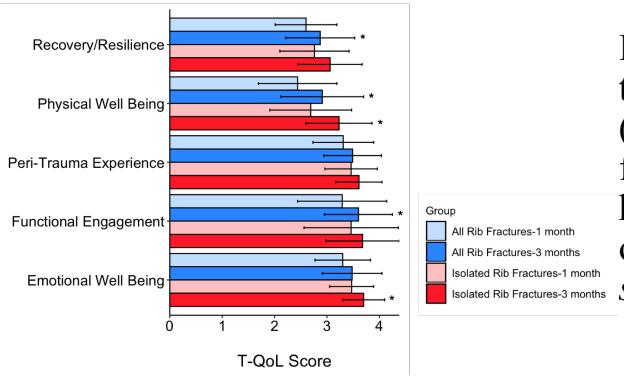


Figure: Trauma Quality of Life (T-QOL) scores for the five QoL domains for patients with rib fractures (all patients and subgroup with isolated rib fractures) at 1 and 3 months after discharge. A higher T-QOL score is associated with a lower risk of post-traumatic stress disorder. **1 vs 3-month scores statistically significant differences at α=0.05*

Session V: Plenary Papers 23-29
Paper 29: 12:35 AM - 12:55 AM

ACQUISITION OF MEDICAID AT THE TIME OF INJURY: AN OPPORTUNITY FOR SECURING INSURANCE COVERAGE

Joshua Jaramillo MD, Katherine Arnow BS, Amber W. Trickey PhD, MSc, Diem Tran PhD, Todd Wagner PhD, Sylvia Bereknyei PhD, Alex HS Harris PhD, MSc, Arden M. Morris MD, MPH, David A. Spain MD, Lisa M. Knowlton MD, MPH
Stanford University Medical Center

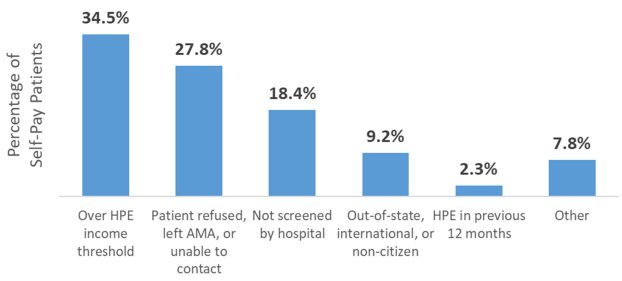
Invited Discussant: Kevin Schuster, MD, MPH

Introduction: Uninsured trauma patients have a higher risk of mortality, inadequate post-discharge resources and catastrophic health expenditure than insured counterparts. Hospital Presumptive Eligibility (HPE), enacted with the 2014 Affordable Care Act, enables hospitals to screen uninsured patients upon hospitalization and initiate Medicaid enrollment. Payer status is recorded at discharge in trauma registries, therefore HPE-approved patients are classified as Medicaid. We aimed to accurately characterize admission insurance status and identify factors associated with acquisition of HPE.

Methods: We identified Medicaid and self-pay patients aged 18-64 with a primary trauma diagnosis (ICD-10) in a large level I trauma center from 2015-2018. We combined trauma registry clinical data with review of electronic medical record case management and social worker notes, to determine our primary outcome of HPE acquisition. Univariate and multivariate analyses were performed.

Results: Among 1,410 patients, 864 (61.3%) had Medicaid and 546 (38.7%) were uninsured at hospitalization. Compared to those with Medicaid on arrival, the uninsured were younger (34 vs. 38 years, $p < .001$), more often male (80.4% vs. 64.9%, $p < .001$) and Hispanic (55.5% vs. 43.5%, $p < .001$). Among those uninsured at arrival, 242 (44.3%) received HPE approval before discharge, and 304 (55.7%) remained self-pay. Demographics were similar between HPE patients and remaining uninsured; however, HPE patients had higher injury severity score (ISS > 15: 14.9% vs. 5.6%, $p < .001$), longer median length of stay (LOS) (1 [IQR: 0,5] vs. 0 [0,1] days, $p < .001$), were more frequently admitted as inpatients (61.5% vs. 34.5%, $p < .001$) and discharged to post-acute services (13.2% vs. 0.7%, $p < .001$). Patient, hospital and policy factors contributed to HPE non-approval (Figure 1). In adjusted analyses, discharge to post-acute services (vs. home: aOR 11.5, $p < .001$) and increasing hospital LOS ($p \leq .003$) were associated with increased likelihood of HPE.

Figure 1. Reasons HPE Not Approved Among Self-Pay Patients



Conclusion: Time-of-injury hospitalization is an underutilized opportunity for intervention, whereby uninsured patients can obtain coverage and improve healthcare access. We identified individual, hospital and policy-level opportunities to increase HPE acquisition, which merit further study nationally across trauma centers. As administrative and trauma registry data do not distinguish between HPE and traditional Medicaid patients, prospective insurance data collection could identify targets for intervention.

TIME IS OF THE ESSENCE: THE RELATIONSHIP BETWEEN TIMING OF AMPUTATION AND COMPLICATIONS AMONG PATIENTS WITH A MANGLED LOWER EXTREMITY

Bourke Tillmann MD, Matthew Guttman MD, Avery B. Nathens MD, PhD, MPH, Charles de Mestral MD, PhD, Ahmed Kayssi MD, MSc, MPH, Barbara Haas MD, PhD
Sunnybrook Health Sciences Centre

Invited Discussant: Kenji Inaba, MD

Introduction: Although extremities are the most commonly injured body region, management of the severely injured, or "mangled", lower limb poses a substantial challenge. While new surgical techniques have led to an increased ability to perform limb salvage, multiple studies suggest limb salvage does not improve functional outcomes or quality of life as compared to amputation. Moreover, efforts to salvage a mangled extremity may, in some patients, simply delay an eventual amputation. This delay potentially contributes to increased complications and mortality. However, the relationship between the timing of amputation and outcomes is unknown. The objective of this study was to evaluate the relationship between amputation timing and mortality among patients with a mangled lower extremity.

Methods: We performed a retrospective cohort study using data derived from the American College of Surgeons Trauma Quality Improvement Program (2012–2017). We included adult patients who sustained a mangled lower extremity and were treated at a Level I trauma center. A patient was identified as having a mangled extremity if they sustained either 1) a severe crush injury (Abbreviated Injury Scale score ≥ 3) or 2) a severe fracture with associated injuries of two or more of soft tissues, arteries, or nerves. Early amputations were defined as those that occurred within 24 hours of presentation. We compared mortality between patients who underwent early amputation and those treated with the intention of limb salvage. Secondary outcomes included hospital length of stay (LOS), severe sepsis, acute kidney injury, and decubitus ulcers. Given that the decision between timing of amputation and outcomes is likely confounded by patient and injury characteristics, instrumental variable analysis was used to adjust for this confounding.

Results: We identified 4,987 patients with a mangled lower extremity across 209 centers, of which 848 (17.0%) underwent an early amputation. In unadjusted analyses, mortality rates were significantly higher among patients who underwent an early amputation as compared to those treated with the intention of limb salvage (10.6% vs 5.2%; RR 2.10, 95% CI 1.65 – 2.67). After controlling for confounding, there was no association between early amputation and mortality (OR 1.39; 95% CI 0.66 – 2.93). However, early amputation was associated with shorter LOS (RR 0.73; 95% CI 0.51 – 0.95), and lower odds of severe sepsis (OR 0.42; 95% CI 0.20 – 0.88) and developing a decubitus ulcer (OR 0.50; 95% CI 0.27 – 0.96).

Conclusion: Among patients who sustained a mangled lower extremity, early amputations were associated with shorter hospital LOS and fewer complications with no difference in mortality. Given the elevated risk of short-term complications and lack of evidence of improved long-term functional and psychological outcomes, attempts at limb salvage should focus on those with highest probability of good functional outcomes, with careful consideration of elevated short-term risks.

EXTRATHORACIC POLYTRAUMA DYSREGULATES NEUTROPHIL FUNCTION AND EXACERBATES PNEUMONIA-INDUCED LUNG INJURY

Christina X. Zhang MD, Anja Fuchs PhD, Sarbani Ghosh MSc, Shin-Wen Chang BS, Liang Lu MD, PhD, Celeste Cummings, Regina Clemens MD, PhD, Mark Hoofnagle MD, PhD, Grant V. Bochicchio MD, MPH, Isaiah Turnbull MD, PhD, Jennifer Leonard MD, PhD
SUNY Downstate

Invited Discussant: Addison May, MD, MBA

Introduction: 40% of trauma patients admitted to the ICU will develop an infectious complication, and pneumonia is the most common cause of death of trauma patients surviving the initial insult. We previously demonstrated that extrathoracic polytrauma (EP) induces emergency hematopoiesis, characterized by accelerated myelopoiesis in the bone marrow (BM) and increased myeloid cell frequency in the peripheral tissues. We hypothesized that EP causes polymorphonuclear neutrophil (PMN) priming which would exacerbate the immunopathology induced by pneumonia in injured animals.

Methods: C57BL/6 mice were subjected to polytrauma consisting of a lower extremity pseudofracture, liver crush injury, and 15% blood-volume hemorrhage. Pneumonia was induced by intratracheal injection of $5x10^6$ CFU *P. aeruginosa* (PA) or secondary acute lung injury was induced by injection of $1x10^7$ of heat-killed PA (HKPA). To measure lung permeability, 20ul of 10mg/kg FITC-conjugated dextran (FD) was injected intratracheally 24hr after trauma, and FD was measured in the plasma 1hr after injection. PMNs were isolated by immunomagnetic bead-mediated negative selection with biotin-labeled antibody cocktail, and ROS production was measured by Luminol fluorescence. Survival was compared by Log-Rank test; bivariate comparisons were by Mann-Whitney U-Test.

Results: Pneumonia after EP resulted in significantly lower survival than those in sham-manipulated mice (95% vs. 40%, $p < 0.05$). EP also caused increased lung permeability when compared to naïve mice (1091 vs. 236 ng/ml FD in the plasma, $p=0.02$). Neutrophils in BM and blood from EP mice had significantly higher resting (unstimulated) ROS production than those isolated from naïve animals demonstrating priming of the neutrophils following EP (Figure 1A). After intra-tracheal HKPA injection to both naïve and EP mice, BAL PMNs from trauma mice had significantly higher resting ROS production (Figure 1B).

Conclusions: EP primes neutrophils and causes immunopathologic PMN ROS production, breakdown of the lung epithelial barrier, increased pulmonary epithelial damage and susceptibility to secondary bacterial pneumonia. These results suggest that trauma induced immune dysfunction can exacerbate the immunopathology caused by infection and propose neutrophil mediated pulmonary damage as a therapeutic target for post-trauma pneumonia.

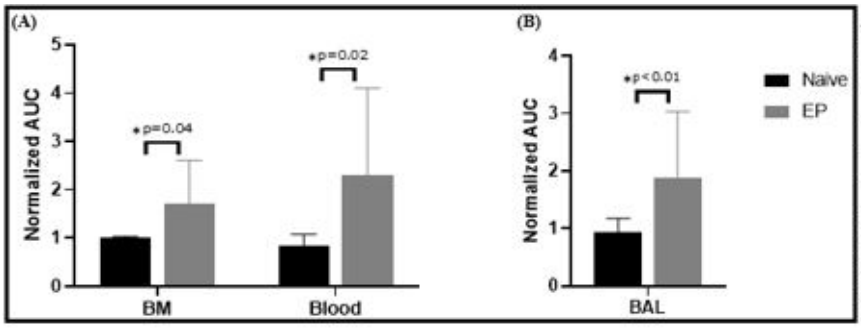


Figure 1. ROS production by neutrophils from BM, blood, and BAL. AUC were calculated after measuring ROS production over 60 minutes of neutrophils from mice with EP alone (A), or with EP and HKPA injection (B). AUC value were normalized to those from naïve mice. BAL = Bronchoalveolar Lavage; BM = Bone Marrow; EP = Extrathoracic Polytrauma; AUC = Area under the Curve; HKPA = Heat-killed *P. aeruginosa.*

TRAUMA PATIENT VS. CAREGIVER SATISFACTION WITH DELIVERY OF PALLIATIVE CARE: WHO FACES THE BURDEN?

Constance McGraw MPH, Rebecca Vogel MD, Pamela Bourg, Diane Redmond, Jennifer Pekarek, Chester Dreiman MD, Allen Tanner, Neal Lynch, David Bar-Or MD
Swedish Medical Center

Invited Discussant: Leah Tatebe, MD

Background: Although the reciprocal nature of the patient-caregiver relationship is evident in palliative care (PC), very few studies actually report on the transactional influence of the patient to the caregiver. Particularly for older patients following traumatic injury, families often become surrogate decision makers and have to facilitate challenging conversations about end-of-life care. The purpose of this study was to compare trauma patient satisfaction to caregiver satisfaction during delivery of PC.

Methods: This was a prospective cross-sectional study over two years (11/2016-11/2018) and included trauma patients ≥ 55 years and their primary caregivers. Two ACS-verified Level I trauma centers in Colorado contributed data. Consented patients and their primary caregivers were administered satisfaction surveys prior to discharge; patients took the Family Satisfaction with Advanced Cancer Care Scale (FAMCARE-P-13) survey, while caregivers took the FAMCARE survey; higher scores indicate higher satisfaction. Both surveys can be analyzed by four domains: Information Giving, Availability of Care, Physical Care, and Psychosocial Care. Usual care at both facilities closely followed the ACS-TQIP Palliative Care Guidelines. The primary outcome was overall mean patient and caregiver satisfaction by survey domain. Comparisons between patient and caregiver satisfaction were analyzed using paired samples t-tests. Satisfaction was also examined with paired t-tests across four PC assessments: consultation, prognostication screenings, formal family meetings, and advanced goals of care discussion.

Results: There were 451 patient and caregiver pairs enrolled. There were no significant differences between patient and caregiver satisfaction across the four survey domains: information giving, availability of care, physical care, and psychosocial care. There were significant differences when satisfaction between patients and caregivers was examined by PC assessment component, Table1. Caregivers had lower satisfaction compared to patients with physical care and psychosocial care when there was a consultation, lower satisfaction with information giving, physical care, and psychosocial care when they had a prognostication screening, and lower satisfaction in every domain when they had a formal family meeting. Conversely, caregivers had significantly higher satisfaction with availability of care when there was an advanced goals of care discussion, compared to patients.

Conclusions: Caregivers often reported significantly lower satisfaction with PC than patients; this was particularly true for caregiver satisfaction with both prognostication screenings and formal family meetings. Our data suggest that caregivers may be receiving some of the patient burden; thus, there is room for improvement in delivery of prognostic information to family members during family meetings and throughout hospitalization.

Table 1. Mean (SD) Satisfaction Between Matched Patients and Caregivers, by Palliative Care Assessment

Survey domain	Consultation	Prognostication	FFM	AGOC
Information Giving	86.3% (14.1) vs. 83.3% (14.4)	83.9% (15.5) vs. 79.7% (16.7)*	86.1% (13.8) vs. 81.6% (14.2)**	82.4% (14.4) vs. 84.0% (13.8)
Availability of Care	88.0% (13.4) vs. 85.6% (14.3)	85.7% (15.5) vs. 83.0% (16.5)	87.8% (13.4) vs. 84.9% (14.0)*	84.4% (14.0) vs. 86.8% (14.1)*
Physical Care	86.7% (13.5) vs. 83.3% (14.1)*	85.3% (15.4) vs. 81.3% (15.3)*	86.7% (13.5) vs. 82.3% (13.3)**	82.8% (14.0) vs. 84.2% (13.5)
Psychosocial Care	89.5% (14.0) vs. 85.7% (14.5)*	89.5% (14.0) vs. 85.7% (14.5)**	89.6% (14.7) vs. 85.3% (14.2)**	85.9% (14.9) vs. 87.0% (14.1)

FFM, formal family meeting; AGOC, advanced goals of care discussion; SD, standard deviation. *indicates significance 0.01-0.04; **indicates significance <0.01. Reported as patient vs. caregiver satisfaction.

ARE LEGALLY PURCHASED GUNS TO BLAME FOR OVERALL FIREARM MORTALITY? A STATE-LEVEL ANALYSIS OF THE ASSOCIATION BETWEEN FIREARM RETAIL AVAILABILITY AND FIREARM MORTALITY

August C. Houghton BS, Sharven Taghavi MD, Eman Toraih MD, Caroline Granruth BS, McGrew Patrick MD, Chrissy Guidry MSc, DO, Rebecca Schroll MD, Maureen Lichtveld MD, MPH, Juan C. Duchesne M.D.
Tulane University School of Medicine

Invited Discussant: Nina Glass, MD

Introduction: In efforts to decrease overall gun-violence mortality, firearm legislation frequently seeks to exert influence on the retail segment. However, the relationship between the retail availability of firearms and firearm mortality has not been clearly demonstrated. We hypothesized that increased firearm retail availability would correlate with higher rates of both firearm homicide and firearm suicide mortality.

Methods: This cross-sectional analysis utilized Federal Firearms and Explosives License (FFL) data obtained from the Bureau of Alcohol, Tobacco, Firearms and Explosives (ATF). Licensed firearm retail locations (LFRs) were defined as FFL Types 01, 02, and 07 with listed business names and addresses. For each state, the number of LFRs was normalized per 100,000 residents. State-level firearm homicide and suicide rates from 2015-2017 were obtained from the Centers for Disease Control. Additionally, several categories of state-level demographic data were gathered for further analysis. Spearman's Rho was performed. Individual linear regression models were then constructed for firearm homicide and firearm suicide mortality.

Results: In total, 50,339 U.S. LFRs were identified (Fig. 1). On the state-level, multiple significant correlations were identified between variables. The strongest correlation observed was between the number of LFRs and suicide rate (0.79, $p < 0.001$) (Fig. 2). No significant relationship was observed between number of LFRs and firearm homicide rates (-0.119, p=0.41). In linear regression analysis, number of LFRs was an independent predictor of suicide mortality (0.173, $p < 0.001$) but not of firearm homicide mortality (Table 1).

Conclusion: Our analysis demonstrated a significant correlation between firearm retail availability and firearm suicide but not firearm homicide mortality. Completed suicides account for nearly two-thirds of U.S. gun deaths, and strong evidence suggests many of these tragedies are shockingly impulsive in nature. Moderate legislative approaches such as mandatory point-of-sale waiting periods may be beneficial in reducing firearm deaths by suicide.

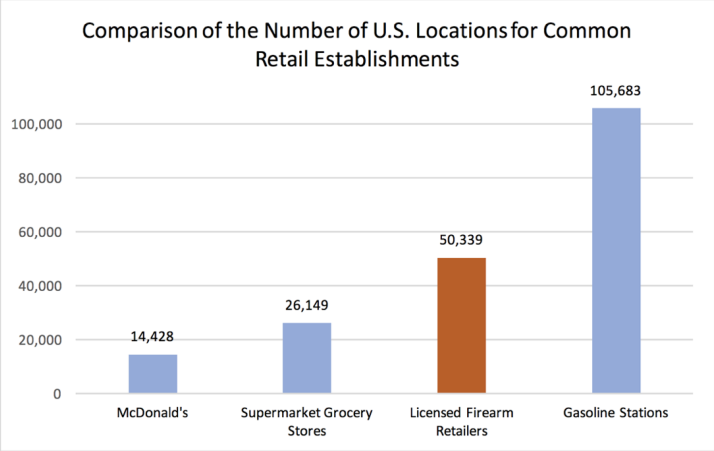


Fig. 1. There are more Licensed Firearm Retailers in the U.S. than McDonald's locations and Supermarket Grocery Stores. (McDonald's, 2019) (FoodIndustry.com, 2019) (U.S. Bureau of Labor Statistics, 2019).

Fig. 2. Spearman's rho correlation matrix was used. Only correlation coefficients of significant correlations are shown. HS: high school

Table 1. Independent predictors for mortality.

Outcome	Independent factors	Beta	95% confidence interval		P value
			Lower limit	Upper limit	
Homicide Mortality	Violent Crime Rate	0.010	0.006	0.014	<0.001
	Poverty Rate	0.393	0.217	0.570	<0.001
	HS Graduation Rate	0.119	0.0003	0.237	0.049
Suicide Mortality	Licensed Firearm Retailers	0.173	0.142	0.203	<0.001
	Poverty rate	0.344	0.167	0.522	0.001

Linear regression analysis was applied using stepwise method. HS: high school.
Adjusted R^2 of the models were 58.4% and 74.4% for homicide and suicide rates, respectively.

DEVELOPING COMMUNITY-BASED SOLUTIONS TO INTERPERSONAL FIREARM VIOLENCE: THE DIFFERING PERSPECTIVES OF SURVIVORS AND TRAUMA SURGEONS

Bachar N. Halimeh, Dorothy Hughes PhD, Blake Evans, Figueroa Julia,
Tanya L. Zakrison MD, MPH, Robert D. Winfield MD
Kansas University Medical Center

Invited Discussant: Srephanie Bonne, MD

Introduction: Interpersonal firearm violence remains epidemic in the United States. Treating survivors without understanding and addressing root causes will ultimately prove ineffective. We hypothesized that interviewing survivors of interpersonal firearm violence and the trauma surgeons who treated them would reveal similarities and differences in perspectives on firearm violence, helping to improve patient care and revealing new ideas to reduce firearm violence.

Methods: Between July 2017 and January 2020, this mixed methods study employed criterion-based sampling to collect quantitative and qualitative data from adult survivors of interpersonal firearm violence presenting and the surgeons who treated them at our ACS Verified Level I trauma center. Quantitative data were collected using closed-ended surveys. Semi-structured interviews were conducted using guides inquiring about perceptions of firearm violence causes and solutions. Quantitative data were analyzed by calculating descriptive statistics by survey question. Qualitative data were coded using the interview guide as an a priori codebook, analyzed for themes within codes, then themes were compared for similarities and differences across participant groups. Qualitative and quantitative data were triangulated to better understand differences and similarities in perspectives among survivors and surgeons.

Results: A total of 10 trauma surgeons and 51 patients participated between July 2017 and January 2020. Patients were younger than surgeons (29 vs. 42 years, p=0.005) and more frequently African American (62 vs. 10%, p=0.007); both groups were predominantly male (84 vs. 90%, p=1). Triangulated data showed consensus among survivors and surgeons that endemic community violence and easy access to firearms were leading causes of firearm violence. Survivors also reported a lack of conflict mediation skills as causal, whereas surgeons cited poverty and unhealthy family dynamics. Survivors and surgeons agreed improved employment and education opportunities and community outreach could be effective in addressing firearm violence. Survivors recommended conflict resolution education; in contrast, surgeons recommended increased police presence. Survivors and surgeons strongly agreed trauma centers could help by providing education and community outreach. A few survivors noted the utility of interview data in accomplishing these ends, stating survivor stories could be effective in deterring firearm violence.

Conclusion: While there was more agreement than not between surgeons and patients in regarding causative and mitigating factors, key differences in perspectives existed. These data supported the importance of community- and trauma-informed care initiatives to bridge gaps between afflicted populations and surgeon-driven hospital-based violence intervention programs.

CAUGHT IN THE CROSSFIRE: 37 YEARS OF FIREARM VIOLENCE AFFLICTING AMERICA'S YOUTH

Nathan Manley MD, Richard Lewis MD, Dih-Dih Huang MD, Tiffany K. Bee MD, Peter Fischer MD, MSc, Martin A. Croce MD, Louis J. Magnotti MD, MSc
University of Tennessee Health Science Center

Invited Discussant: Dennis Vane, MD, MBA

Introduction: Publicly available firearm data is difficult to access. Trauma registry data is excellent at documenting patterns of firearm-related injury. Law enforcement data excels at capturing national violence trends to include both circumstances and firearm involvement. The goal of this study was to utilize publicly available, law enforcement data from all 50 states to better define patterns of firearm-related homicides in the young.

Methods: All homicides in individuals $\leq$ 25 years old in the United States over a 37-year period ending in 2016 were analyzed: infant $\leq$ 1 year old, child 2-9 years old, adolescent 10-19 years old, young adult 20-25 years old. Primary data files were obtained from the Federal Bureau of Investigation and comprised the database. Data analyzed included homicide type, situation, circumstance, month, firearm type and demographics. Rates of all homicides and firearm-related homicides per 1 million (M) population and the proportion of firearm-related homicides (out of all homicides) were stratified by year and compared over time using simple linear regression.

Results: 171,113 incidents of firearm-related homicide were analyzed (69% of 246,437 total homicides): 5313 infants, 2332 children, 59,777 adolescents and 103,691 young adults. Most were male (79%), black (50%) with a mean age of 18. Firearm-related homicides peaked during the summer months of June, July and August (median = 1156 per year; $p = 0.0032$). Rates of all homicides (89 to 53 per 1M population) and firearm-related homicides (56 to 41 per 1M population) decreased significantly from 1980 to 2016 ($\beta = -1.12$, $p < 0.0001$ and $\beta = -0.57$, $p = 0.0039$, respectively). However, linear regression analysis identified a significant increase in the proportion of firearm-related homicides (out of all homicides) from 63% in 1980 to 76% in 2016 ($\beta = 0.33$, $p < 0.0001$).

Conclusions: For those 25-years-old and younger, the proportion of firearm-related homicides has steadily and significantly increased over the past 37-years, with three out of four homicides firearm-related in the modern era. Despite focused efforts, reductions in the rate of firearm-related homicides still lag behind those for all other methods of homicide by nearly 50%. That is, while the young are less likely to die from homicide, for those unfortunate victims, it is more likely to be due to a firearm. This increasing role of firearms in youth homicides underscores the desperate need to better direct prevention efforts and firearm policy if we hope to further reduce firearm-related deaths in the young.

A PSEUDO-DILEMMA: ARE WE OVER-DIAGNOSING AND OVER-TREATING TRAUMATIC SPLENIC INTRAPARENCHYMAL PSEUDOANEURYSMS?

Sydney Radding MD, Ara Ko MD, MPH, Rishi Kundi MD, Jonathan Morrison MD, PhD, Rosemary A. Kozar MD, PhD, John S. Maddox MD, Jason Radowsky MD, Joseph J. DuBose MD, David V. Feliciano MD, Thomas M. Scalea MD
University of Maryland, Shock Trauma Center

Invited Discussant: Ben Zarzaur, MD, MPH

Introduction: Splenic embolization for traumatic vascular abnormalities in stable patients is a common practice. We hypothesize that modern contrast-enhanced CT identifies unimportant post-traumatic splenic vascular lesions such as intraparenchymal pseudoaneurysms (PSA), perhaps altering the indication for splenic embolization.

Methods: After IRB approval, we reviewed our high-volume center experience with the endovascular management of splenic injuries from Sep 2014-Nov 2018. Multidisciplinary review was used to compared initial CT findings to subsequent angiography, analyzing management and outcomes of identified PSAs.

Results: Of 717 splenic injuries managed overall during the study period, 155 (21.6%) underwent embolization and 140 (19.5%) had adequate imaging available for review. All patients had blunt trauma, 65.7% were male, and 2.1% presented with systolic blood pressure < 90 mm Hg. Mean age was 43, and mean ISS was 22 ± 9. AAST splenic injury grades included Grades 2 (6.4%); 3 (31.4%), 4 (61.4%) and 5 (0.7%). Vascular injuries identified on initial CT were active extravasation in 17.1% and PSA in 52.1%. Angiography was performed a mean of 17 hours after admission, with 44.3% done within 6 hours. Subsequent embolization was performed for 87.9% using coils (74), plug devices (43) or both (6). Among the 73 patients with PSA on initial CT, 24 (32.9%) had no visible lesion on subsequent angiogram. Embolization for angiogram confirmed PSA was undertaken in 87.8% (43/49). On post-embolization CT at 48-72 hours, persistently perfused splenic PSAs were seen in 39.5% (17/43) of those with and 66.7% (4/6) without embolization. No patients with PSA on angiography who was observed without embolization required delayed splenectomy, whereas 4.7% (2/43, p = 1.00) in the embolized group had splenectomy at 74.7 and 288.0 hrs after admission.

Conclusion: Modern CT may identify clinically insignificant splenic PSAs in a third of patients. Even when identified at angiogram and embolized, 40% of traumatic PSAs will remain perfused during hospitalization.

Session VI: Plenary Papers 30-37
Paper 37: 11:20 AM - 11:40 AM

ENHANCING TRAUMA REGISTRIES BY INTEGRATING TRAFFIC RECORDS AND GEOSPATIAL ANALYSIS TO IMPROVE BICYCLIST SAFETY

Jay J. Doucet MD, MSc, Laura N. Godat MD, Leslie M. Kobayashi MD, Allison E. Berndtson MD, Amy Liepert MD, Eric Raschke DO, John Denny, Alan Smith PhD, Todd W. Costantini MD
UC San Diego Division of Trauma, Surgical Critical Care and Burns

Invited Discussant: Louis Magnotti, MD,MSc

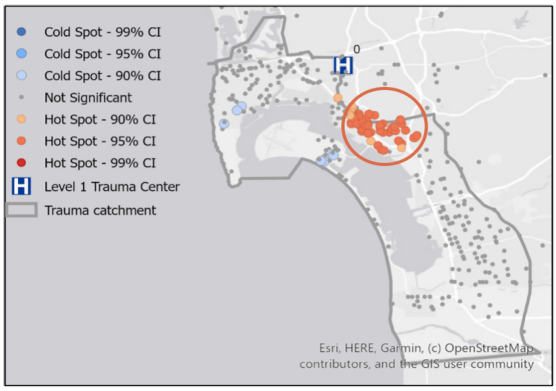
Background: Trauma registries are used to identify modifiable injury risk factors for trauma prevention but lack data useful for prevention of bicycle-automobile collisions such as vehicle speeds, driver intoxication, street conditions and neighborhood characteristics. We hypothesized that geographic information systems (GIS) analysis of trauma registry data matched with a traffic accident database could identify risk areas for bicycle-automobile injuries to better inform injury prevention efforts.

Methods: The trauma registry of a U.S. Level I trauma center was used retrospectively to identify bicycle-motor vehicle collision admissions from 2010 to 2018. Data collected included demographics, vitals, injury severity scores, toxicology, helmet use and mortality. Matching with the statewide integrated traffic records system (SWITRS) was done to provide collision, victim and GIS data. Mapping was done with census tract data including poverty levels. Hot spot analysis to identify statistically significant incident clusters was done using the Getis Ord Gi* statistic.

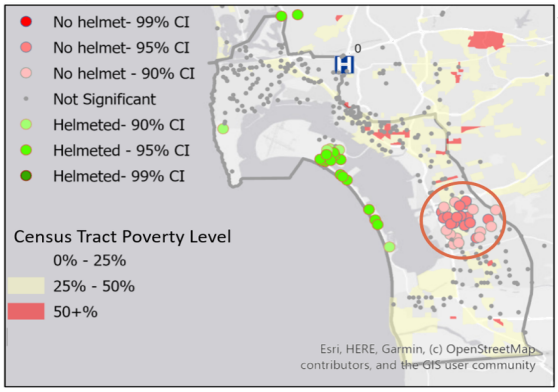
Results: Out of 25,535 admissions, 531(2.1%) were bicyclists struck by automobiles, 425 (80.0%) were matched to SWITRS. There were 5 bicyclist scene deaths and 11 (2.5%) deaths after admission. Alcohol intoxication was involved in 13.4% of bicyclists but 20% of drivers, and in 50% of fatalities (P=0.004). Bicyclists had higher tract poverty rates than the county mean (18.53% vs 14.3%, P < 0.001). Collisions in poorer census tracts had less helmet use (24.7% vs 36.7%, P=0.012) and more drivers at-fault (25.6% vs. 20.5%, P=0.022). GIS analysis identified hot spots for intoxicated drivers or bicyclists (Z score=3.3; P=0.002) and lack of helmet use (Z score=3.4; P=0.001, see figures 1, 2.)

Conclusions: Combining trauma registry data and traffic records with GIS analysis identifies additional risk factors for bicyclist injury. Trauma centers should lead efforts to prospectively link public traffic accident data to their registries to better target injury prevention.

1. Hotspots – driver/cyclist intoxication



2. Hotspots – helmet use



REGIONALIZATION OF TRAUMA CARE BY OPERATIVE EXPERIENCE: DOES THE VOLUME OF EXPLORATORY LAPAROTOMY MATTER?

Andrew Tang MD, Mohamad Chehab MD, Kamil Hanna MD, Michael Ditillo DO, Lourdes Castanon MD, Letitia Bible MD, Molly Douglas MD, Samer Asmar MD, Bellal Joseph MD
University of Arizona

Invited Discussant: Brian Eastridge, MD

Introduction: The volume-outcome relationship led to the regionalization of trauma care. The relationship between the trauma center's laparotomy volume and outcomes is not well explored. The aim of our study is to evaluate the impact of laparotomy volume on outcomes in blunt and penetrating trauma patients.

Methods: We performed a (2017) analysis of the ACS-TQIP database. We included adult (≥18y) blunt and penetrating trauma patients who required exploratory laparotomies for hemorrhage control. Trauma centers were stratified based on each center's penetrating and blunt laparotomy volumes. (HV: high volume:>20 cases/year, MV: medium volume 10-20 cases/year, LV: low volume <10 cases/year). Primary outcomes were 24-hour mortality and in-hospital mortality. Secondary outcomes were major complications and time to hemorrhage control. Regression analysis was performed controlling for demographics, injury parameters, transfusions remaining center characteristics.

Results: A total of 9,381 patients were included of which 5,396 had blunt injuries and 3,985 had penetrating injuries. Overall, the mean age was 39±18y, abdomen AIS was 3[3-4], and ISS was 48[27-66]. For ACS Level I centers: 40% were HV, 45% MV, and 15% LV. For ACS Level II centers: 10% were HV, 30% MV, and 60% LV. For ACS Level III centers: 0% were HV, 61% MV, and 39% LV. On regression analysis, admission of penetrating trauma patients to HV penetrating trauma laparotomy centers was independently associated with improved 24-hour and in-hospital mortality. A similar trend was observed for blunt trauma patients. No association was found between major complications and center volume for neither mechanisms of injury. **Table 1**. HV penetrating trauma centers had a significantly lower time to hemorrhage control (35 [26-53] min) vs. MV (40 [29-63] min) and LV centers (45 [31-66] min) (p<0.01). The same trend was observed for HV blunt trauma centers (73 [41-145] min) vs. MV (82 [50-147] min) and LV centers (93 [56-158] min) (p<0.01).

Conclusion: Severely injured patients requiring laparotomy had higher survival when admitted to trauma centers with HV operative experience for their particular mechanisms of injury. The regionalization of trauma care should be based on a thorough evaluation of the center's operative experience with different mechanisms of injury.

Table 1: Multivariable Regression Analysis

	Penetrating Injuries (N=3985)			Blunt Injuries (N=5396)		
Outcome	**LV (N=1185)**	**MV (N=1588)**	**HV (N=1212)**	**LV (N=1239)**	**MV (N=2299)**	**HV (N=1858)**
24-Hour Mortality	Ref	0.99 [0.92-1.07]	**0.76 [0.71-0.83]***	Ref	0.96 [0.77-1.20]	**0.76 [0.60-0.96]***
In-Hospital Mortality	Ref	1.02 [0.92-1.12]	**0.86 [0.77-0.96]***	Ref	0.95 [0.79-1.14]	**0.83 [0.68-0.73]***
Major Complications	Ref	1.01 [0.74-1.34]	0.82 [0.69-1.34]	Ref	1.07 [0.91-1.26]	0.76 [0.71-1.44]

LV=Low Volume (<10 cases/year); MV=Medium Volume (10-20 cases/year); HV=High Volume (>20 cases/year); *=p<0.05

USE OF RESUSCITATIVE ENDOVASCULAR BALLOON OCCLUSION OF THE AORTA IN TRAUMATIC BRAIN INJURY PATIENT: A NATIONWIDE ANALYSIS

Muhammad Khurrum MD, Michael Ditillo DO, Molly Douglas MD, Letitia Bible MD, Lourdes Castanon MD, Mohamad Chehab MD, Andrew Tang MD, Narong Kulvatunyou MD, Bellal Joseph MD
University of Arizona

Invited Discussant: A. Britton Christmas, MD

Introduction: Resuscitative endovascular balloon occlusion of the aorta (REBOA) has emerged as a non-invasive alternative to resuscitative thoracotomy for noncompressible torso hemorrhage. The use of REBOA in animal models revealed worsening traumatic brain injury (TBI) due to increase intracranial pressure. There is a paucity of clinical data regarding its effect in severe TBI patients. The aim of our study was to evaluate the effect of REBOA on outcomes in severe TBI patients.

Methods: We performed a retrospective analysis of the 2017 American College of Surgeons Trauma Quality Improvement Program. We include adult (age ≥18y) TBI (Head AIS ≥ 3) patients. Patients who were dead on arrival, transferred and had prehospital cardiac arrest were excluded. Patients were stratified into: those who underwent REBOA within 1 hour of presentation (REBOA group) and those who did not (no-REBOA group). Propensity score matching was performed (1:2 ratio) adjusting for demographics, vital signs, injury-parameters, and blood products transfused. Outcomes were the rates of complications, length of stay (LOS), and mortality.

Results: Of 501,155 adult TBI patients, a matched cohort of 486 patients (162 REBOA and 324 no-REBOA group) was obtained. Mean age was 41±18y, head-AIS was 3 [3-4], and ISS was 56 [41-72]. Patients in the REBOA group had a significantly longer LOS (16 [5-31] d vs. 10 [2-33] d; $p < 0.01$). Patients in the REBOA group also had higher rates of in-hospital mortality (43.2% vs. 29.9%; $P < 0.01$), 24-hour mortality (32.1% vs. 17.1%; $p < 0.01$), cardiac arrest (21% vs 8.6%; $p < 0.01$), pulmonary embolism (6.2% vs 2.5% ; $p = .04$), unplanned intubation (4.1% vs. 0.9%; $p < 0.01$), acute kidney injury (6.7% vs. 2.5%; $p = 0.03$) and lower-extremity amputation (4% vs. 0.8%; $p < 0.01$).

Conclusion: REBOA in severe TBI patients was associated with worse outcomes compared with a similar cohort of patients who did not undergo REBOA. The decision to use REBOA should be carefully considered in the presence of a TBI. Future studies are required to clearly demarcate the use of REBOA in this subgroup of trauma patients.

Session VII: Plenary Papers 38-44
Paper 40: 9:40 AM - 10:00 AM

MULTI-INSTITUTIONAL VALIDATION STUDY OF THE INJURED TRAUMA SURVIVOR SCREEN (ITSS)

Joshua C. Hunt PhD, Erick Herrera-Hernandez BS, Kelley Jazinski-Chambers BS, Amber Brandolino MSc, Katy Maher PhD, Brianna Jackson BS, Randi N. Smith MD, MPH, Diane Lane BS, Mackenzie Cook MD, Karen J. Brasel MD, MPH, Marc A. de Moya MD, Terri deRoon-Cassini PhD
Medical College of Wisconsin

Invited Discussant: Rachael Callcut, MD

Background: Development of posttraumatic stress disorder (PTSD) or a major depressive episode (MDE) are common following traumatic injury, occurring in up to 20% of US trauma survivors. This led to the American College of Surgeons-Committee on Trauma (ACS-COT) recommendation to screen for these disorders in trauma centers. The nine-item Injured Trauma Survivor Screen (ITSS) has previously been shown to predict PTSD and MDE risk at 1- and 6-months after traumatic injury. We hypothesized that the ITSS would retain high sensitivity when compared to more time-consuming, symptom-based measures in a AAST sponsored multi-institutional validation study.

Method: Patients were enrolled following admission to one of four Level I trauma centers. All participants (N = 375) were administered the ITSS. Symptom-based measures were included as a proxy for detailed evaluation of acute psychological distress, evaluated in a second post-screening step, to enhance specificity of the overall psychodiagnostic evaluation and reduce false positives. The PTSD Checklist for *DSM-5* (PCL-5), and the Center for Epidemiological Studies Depression Scale Revised (CESD-R) were administered during initial hospitalization, an average of 3.88 days after injury (SD = 3.26). The Clinician Administered PTSD Scale for *DSM-5* (CAPS-5) and the CESD-R were administered at follow-up, an average of 1.2 months after injury (SD = .473), to generate binary diagnostic (Yes-present / No-absent) categories.

Results: The rate of PTSD in the sample was 20.5% (n = 46) and the rate of MDE was 15.25% (n = 34). The ITSS PTSD Scale (n = 224, additional participant data is still being entered) had a sensitivity of 73.91% (n = 34/46), specificity 63.48 %, NPV 90.7%and PPV 33.6% (AUC = .687, 95% CI = 0.622, 0.747). The combined risk group increased the specificity to 80.34%.The ITSS Depression Scale had a sensitivity of 73.53% (n = 25/34), specificity 58.73 %, NPV 89.9% and PPV 30.8 % (AUC = .661, 95% CI = 0.595, 0.723). The combined risk group increased the specificity to 100%.

Conclusions: The short, easy to administer ITSS retained high sensitivity and specificity in a multi-institutional validation study. Symptom-based measures can reduce the false-positive rate for patients that screen positive on the ITSS. Therefore, the ITSS is a viable option for trauma centers with diverse patient populations.

Session VII: Plenary Papers 38-44
Paper 41: 10:00 AM - 10:20 AM

ROADWAY FEATURES ASSOCIATED WITH ELDERLY MOTOR VEHICLE COLLISIONS

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Invited Discussant: Robert Barraco, MD, MPH

Introduction: As the number of older US drivers has increased over the past several decades, so has the number of injuries, hospitalizations, and deaths from motor vehicle crashes (MVCs) involving the elderly. Given the multiple age-related risk factors that contribute to road crashes among the elderly, we seek to identify environmental & road features associated with increased collisions involving elderly drivers.

Methods: This is a retrospective observational study using 2015-2019 Police Department traffic crash reports and a Department of Public Health database of built-environment variables from a single urban center. Demographics and environmental/road features were compared for vehicle-only MVCs involving elderly (≥ 65 years) or younger drivers; crashes involving pedestrians or bicyclists were excluded. Chi-squared and nonparametric tests were used to analyze 36,168 drivers involved in MVCs.

Results: There were 2,575 (7.1%) %) elderly drivers involved in MVCs. Left turns and all-way stop signs were associated with increased risk for these crashes. On the other hand, intersections with left turn restrictions, traffic lights, only one-way streets, and bike lanes were inversely associated. Crashes with elderly drivers were more likely to occur on weekdays. Elderly drivers were less often intoxicated at the time of the crash, but they were more frequently the party at fault when crashes involved multiple vehicles. Elderly drivers were less likely than younger adult drivers to be involved in fatal MVCs.

Conclusion: Updates to built road features have potential to decrease injury and death from MVCs involving elderly adults. Left turn restrictions or other innovative safety treatments at all-way stops or where left turns are permitted may mitigate road crashes involving older adults, who contend with decreased vision and slower response times. Supplemental education of older drivers may increase awareness of higher-risk driving tasks such as turning left as well as driving alternatives including public transportation and paratransit. Since transportation plays an important role in maintaining activities of daily living among elderly adults, safe transportation options and environments and appropriate counseling are necessary to promote safer travel.

Characteristic	Relative Risk for Age ≥65 (n=2,575, 7.1%) vs. <65 (n=33,593, 92.9%)	95% Confidence Interval
Alcohol use	0.45	0.34-0.60
Left turn prior to crash	1.15	1.02-1.23
Left turns prohibited	0.89	0.82-0.97
Traffic light	0.84	0.78-0.91
One-way streets only	0.67	0.57-0.78
Bike lane	0.92	0.85-0.99
All-way stop signs	1.25	1.12-1.41
During weekend	0.85	0.78-0.92

RECENT RELEASE FROM PRISON – A NOVEL RISK FACTOR FOR INTIMATE PARTNER HOMICIDE

Justin Cirone MD, Robert Keskey MD, David Hampton MD MEng, Mark Slidell MD MPH, Marie Crandall MD MPH*, Rishi Rattan MD*, Catherine Velopulos MD MHS**, Debra Allen MSN RN TCRN CCRN-K, Kenneth Wilson MD, Tanya L. Zakrison MD MPH
University of Chicago, *University of Florida, **University of Colorado

Invited Discussant: D'Andrea Joseph, MD

Introduction: The United States has the highest per-capita incarceration rate and the largest prison population in the world. The incarceration of individuals has been not been demonstrated to be a successful deterrent to future violence but may in fact be a potent stimulator of this. Despite being among the most closely monitored group of citizens, 60.1% of recently incarcerated individuals will be arrested again within 2 years of release and may even commit crimes as serious as homicide soon after discharge. The pattern of homicidal violence currently remains unknown for these recently incarcerated homicide suspects (RIHS).

Methods: A retrospective analysis of the 36 states included in the 2003-2017 National Violent Death Reporting System Restricted Access Database was performed with focus on incidents where homicide suspects had recent institutionalization status documented. Individuals were identified as being recently incarcerated within the last 30 days, or not recently incarcerated. Pearson's chi-squared and Wilcoxon rank-sum tests were used to compare the RIHS population to the homicide suspect population who were not recently incarcerated.

Results: This database of 14,561 homicides suspects included 249 cases where the suspect had been recently incarcerated. RIHS more commonly had a known relationship with the victim (74.7% vs 50.9%, $p < 0.001$), and these homicides were more likely to be committed in the victim's own home (42.6% vs 34.2%, $p=0.006$). Intimate partner violence was a factor in 30.5% of the RIHS cases (vs 16.8%, $p < 0.001$). The homicide weapon was most likely to be a firearm (57.8%, $p < 0.001$) and the most common firearm type were semi-automatic handguns. Only 6.4% were due to suspect's mental health illness, but recent alcohol (12.9% vs 5.4%, $p < 0.001$) and other substance use (22.9% vs 4.5%, $p < 0.001$) was significantly higher in the RIHS group. While RIHS were more likely to commit homicide for gang-related reasons compared to non-incarcerated suspects, it was only a precipitating factor in 12.0% of the homicides (vs 7.4%, $p=0.006$).

n = 14,561	Not Recently Incarcerated n = 14,312	Recently Incarcerated n = 249	p-value
Age, years, median (IQR)	28.0 (21.0-39.0)	30.0 (24.0-37.0)	0.028
Male Sex	90.7% (10,608)	97.2% (239)	<0.001
Race			<0.001
White	28.6% (3,920)	41.25% (99)	
Black	36.8% (5,034)	42.1% (101)	
Other	34.6% (4,744)	16.7% (40)	
Suspect's Relationship to Victim			<0.001
Victim Knows Suspect	50.9% (7,289)	74.7% (186)	
Stranger	7.7% (1,108)	10.8% (27)	
Unknown	41.3% (5,915)	14.5% (36)	
Victim was a Bystander	1.4% (198)	4.8% (12)	<0.001
Injury Occurred at Victim's Home	34.2% (4,897)	42.6% (106)	0.006
Suspect Previously Abused Victim	3.4% (487)	15.3% (38)	<0.001
Gang Violence Related	7.4% (1,061)	12.0% (30)	0.006
Intimate Partner Violence Related	16.8% (2,401)	30.5% (76)	<0.001
Due to Suspect's Mental Health Illness	3.9% (555)	6.4% (16)	0.040
Suspect Recent Alcohol Use	5.4% (780)	12.9% (32)	<0.001
Suspect Recently Used Substances	4.5% (640)	22.9% (57)	<0.001
Weapon/Means - Top 3			<0.001
Firearm	72.2% (10,081)	57.8% (144)	
Sharp Instrument	12.8% (1,780)	17.7% (44)	
Hanging, Strangulation or Suffocation	3.1% (437)	10.4% (26)	
Firearm Type - Top 3			<0.001
Handgun: Semi-Automatic	19.1% (1,896)	38.7% (55)	
Handgun: Other	44.6% (4,431)	30.3% (43)	
Rifle/Long Gun	4.2% (421)	7.0% (10)	

Conclusions: Homicide suspects who were recently incarcerated were more likely to target a known person in the victim's own home and use a firearm in the crime. Alcohol and other substance abuse is a precipitating factor significantly more often than mental health illness, and these homicides are six times more likely to be due to intimate partner violence than for gang-related reasons. Additional future interventions are urgently needed to eliminate these preventable deaths.

A CLINICAL PRACTICE GUIDELINE USING PERCENTAGE OF PREDICTED FVC IMPROVES RESOURCE ALLOCATION FOR RIB FRACTURE PATIENTS

Joshua Billings MD, Abid Khan MD, L. Paige Clement, Alyssa Douville, Eric Brown, Thomas J. Schroeppel MD,
University of Colorado Health

Invited Discussant: Fredric Pieracci, MD, MPH

Introduction: Although rib fractures are present in approximately 10% of blunt trauma patients, predicting which patients will require higher level care is a challenge during initial triage. Percentage of predicted (PP) forced vital capacity (FVC) better incorporates patient-specific factors to customize the measurements to each patient. A single institution transitioned from a clinical practice guideline (CPG) utilizing absolute FVC to one using PP FVC to improve initial triage of rib fracture patients. This study aims to compare the outcomes of patients before and after the CPG change.

Methods: A review of rib fracture patients was performed over a 34 month retrospective period (RETRO) and 12 month prospective period (PRO). The RETRO cohort was triaged by initial absolute FVC and initial PP FVC was used to triage the PRO cohort. Demographics, mechanism, injury severity (ISS), chest abbreviated injury scale (AIS), number of rib fractures, tube thoracostomy (TT), intubation, admission to ICU, transfer to ICU, hospital length of stay (LOS), ICU LOS, and mortality data were compared. A multivariable model was constructed to perform adjusted analysis for LOS.

Results: 588 patients were eligible for the study with 269 RETRO and 319 PRO patients. No significant differences in age, gender, or injury details were identified between the groups. Fewer TT were performed in the PRO cohort. The groups had similar rates of intubation, admission to ICU, and mortality, however, fewer transfers to the ICU occurred in the PRO cohort. Patients in the PRO cohort had a shorter LOS and ICU LOS. Adjusted analysis with multiple linear regression identified age, ISS, TT, and the PRO cohort as significant predictors of LOS with R^2=0.163.

	Total Study n=588	RETRO n=269	PRO n=319	*p*
Age	60 (47,75)	62 (50,76)	58 (43,74)	0.056
Female	39.1%	38.3%	39.8%	0.706
ISS	13 (9,17)	13 (9,17)	13 (9,17)	0.392
Chest AIS	3 (2,3)	3 (2,3)	3 (2,3)	0.715
Thoracostomy	17.6%	22.3%	13.5%	0.005
Intubation	3.6%	4.5%	2.8%	0.286
Admit to ICU	32.8%	36.1%	30.1%	0.125
Transfer to ICU	9.7%	16.0%	4.4%	<0.001
ICU LOS	0 (0,2)	0 (0,3)	0 (0,1)	<0.001
Hospital LOS	5 (3,7)	5 (4,8)	4 (2,7)	<0.001

Multivariable: LOS	***B***	***SE B***	**Beta**	***p***
Age	0.02	0.01	0.10	0.012
PRO	-1.28	0.37	-0.13	0.001
TT	2.10	0.49	0.17	<0.001
ISS	0.21	0.02	0.33	<0.001

Conclusion: PP FVC better stratified rib fracture patients leading to a decrease in transfers to the ICU, ICU LOS, and hospital LOS. By incorporating patient specific-factors into the triage decision, the new CPG optimized triage and decreased resource utilization over the study period.

Session VII: Plenary Papers 38-44
Paper 44: 11:00 AM - 11:20 AM

DISTINCT IMMUNOLOGIC ENDOTYPES ARE ASSOCIATED WITH CLINICAL TRAJECTORY AFTER SEVERE BLUNT TRAUMA AND HEMORRHAGIC SHOCK

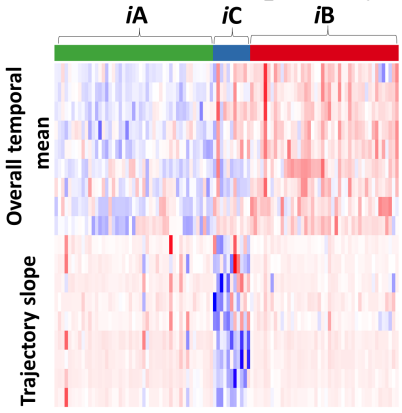
Scott C. Brakenridge MD, Zhongkai Wang MSc, Michael C. Cox MD, Babette Brumback PhD, Alicia M. Mohr MD, Frederick A. Moore MD, Joseph Cuschieri MD, Ronald V. Maier MD, Philip A. Efron MD, Lyle Moldawer PhD
University of Florida

Invited Discussant: Ronald Tompkins, MD

Introduction: The genomic/cytokine "storm" after severe trauma has been well documented. However, the differing composition, magnitude and resolution of this response, and its relationship to clinical outcomes remains unclear.

Methods: This is a secondary analysis of a prospective longitudinal cohort study among severely injured trauma patients with hemorrhagic shock. Peripheral blood sampling was performed at 0.5, 1, 4, 7, 14 and 28 days after injury. Plasma cytokines were measured by Luminex™. K-means unsupervised clustering utilizing overall mean and trajectory slope of selected immunologic biomarkers (IL6, IL8, IL10, IL17, G-CSF, GM-CSF, IP10 & sPD-L1) was used to distinguish temporal immunologic endotypes. Endotypes were compared to known clinical trajectories defined as early death (< 14 days), chronic critical illness (CCI) [≥ 14 days ICU LOS + persistent organ dysfunction] and rapid recovery (RAP) [ICU LOS < 14 days + organ recovery].

Results: The cohort included 102 severely injured patients (ISS=33, IQR 24-41) in hemorrhagic shock (Max. Lactate=4.6, IQR 3.2-6.2) enrolled across two Level 1 trauma centers. We identified 3 distinct immunologic endotypes (*i*A, *i*B, *i*C), each with unique associations to clinical trajectory (p=0.003). Endotype *i*A (n=47) exhibited a moderate initial proinflammatory response followed by a return to immunologic homeostasis, with a primary clinical trajectory of RAP (n=44, 93.6%). Endotype *i*B (n=44) exhibited an early hyperinflammatory response with persistent inflammation and immunosuppression, with the highest incidence of CCI (n=10, 22.7%). Endotype *i*C (n=11) exhibited a similar hyperinflammatory response, but with rapid return to immunologic homeostasis and a predominant trajectory of RAP (n=9, 81.8%). Patients with endotype *i*B had the highest severity/duration of organ dysfunction, highest incidence of nosocomial infections (50%, p=0.001) and was the predominant endotype of patients that developed CCI (10/13 CCI, 76.9%; p=0.002). Endotype *i*B (n=1) and *i*C (n=2) comprised all early deaths.



Conclusion: This study identified three distinct immunologic endotypes after severe blunt injury and hemorrhagic shock differing in the magnitude and duration of the early response. The clinical trajectory of chronic critical illness (CCI) is characterized by an endotype (iB) defined by persistent inflammation/immunosuppression, and is associated with poor clinical outcomes.

PEDIATRIC ADJUSTED REVERSE SHOCK INDEX MULTIPLIED BY GLASGOW COMA SCALE OUTPERFORMS PEDIATRIC ADJUSTED SHOCK INDEX IN PEDIATRIC WAR ZONE TRAUMA

Daniel Lammers MD, Christopher Marenco MD, Woo Do MD, Conner Jeffrey MD, John Horton MD, Matthew Martin MD, Escobar Mauricio MD, Jason Bingham MD, Matthew Eckert MD
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Invited Discussant: Randall Burd, MD, PhD

Introduction: Shock index (SI) and its pediatric adjusted derivative (SIPA) have demonstrated utility as prospective predictors of mortality in adult and pediatric trauma populations. Although basic vital signs provide promise as triage tools, factors such as neurologic status on arrival have profound implications for trauma-related outcomes. Recently, the reverse SI (rSI) multiplied by Glasgow Coma Scale (GCS) (rSIG) has been validated in adult trauma as a tool combining early markers of physiology and neurologic function to predict mortality. This study sought to compare the performance characteristics of rSIG against SIPA as a prospective predictor of mortality in pediatric war zone injuries.

Methods: Retrospective review of the Department of Defense Trauma Registry, 2008 –2016, was performed for all patients less than 18 years old with documented vital signs and GCS on initial arrival to the trauma bay. Optimal age specific cut off values were derived for rSIG via the Youden Index using receiver operating characteristic analyses. Multivariate logistic regression was performed to validate accuracy in predicting early mortality.

Results: A total of 2,007 pediatric patients with a median age range of 7-12, 79% male, average ISS 11.9, and 63% sustaining a penetrating injury were included in the analysis. The overall mortality was 7.1%. A total of 874 (43.5%) and 685 (34.1%) patients had elevated SIPA and pediatric adjusted rSIG (rSIG) scores, respectively. After adjusting for demographics, mechanism of injury, initial vital signs and presenting laboratory values, rSIG (OR=4.054; p=0.013) was found to be superior to SIPA (OR=2.742; p=0.005) as an independent predictor of early mortality.

Conclusion: Pediatric adjusted rSIG more accurately identifies pediatric patients at the highest risk of death following war zone injuries when compared to SIPA alone. These findings may help refine early risk assessments for patient management and resource allocation in constrained settings. Further validation is necessary to determine applicability to the civilian population.

COMPARISON OF MASSIVE AND EMERGENCY TRANSFUSION PREDICTION SCORING SYSTEMS AFTER TRAUMA WITH A NEW BLEEDING RISK INDEX SCORE APPLIED IN-FLIGHT

Shiming Yang PhD, Chien-Yu Lin MSc, Peter Rock MD, MBA, Douglas Floccare MD, MPH, Florian Stumpf BS, Colin Mackenzie MD, PhD, Catriona Miller PhD, Christopher Winans, Samuel Galvagno MD, PhD, Deborah M. Stein MD, MPH, Thomas M. Scalea MD,
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Invited Discussant: Bryan Cotton, MD,MPH

Introduction: Scoring systems such as the Assessment of Blood Consumption (ABC)[1], Revised Trauma Score (RTS) and Shock Index (SI) have been used to estimate the need for emergency blood transfusion. We have developed a Bleeding Risk Index (BRI) based on the autonomous analysis of pulse oximetry photoplethysmographic (PPG), ECG and blood pressure (BP) signals. We hypothesized that in the prehospital environment BRI would have equivalent or better performance compared to ABC, RTS, and SI for predicting the need for emergent and massive transfusion

Methods: We analyzed data from 1,396 adult trauma patients transported directly to a level I trauma center from the scene via helicopter from January 2016 to December 2017. The BRI score was calculated based on the features derived from the PPG and ECG waveforms at 240Hz and oximetry SpO2 and BP trends at 0.5Hz. The ABC, RTS and SI were calculated using admission data. The area under the receiver operating characteristic curve (AUC) with 95% confidence interval (CI) was calculated for predictions of Critical Administration Threshold (CAT: ≥3 units of pRBC in the first hour) or Massive Transfusion (MT: ≥ 10 U of blood in the 1st 24 hour). We consider the difference in AUCs was statistically significant when the AUCs 95% CI range does not overlap.

Result: Among the 1,396 patients, the mean age was 46.5 ± 20.1 (SD) years, 67.1% were male, the MT rate was 3.4%, and CAT 7.7%. Proportion blunt to penetrating injury was 1:13. The mortality rate was 6.6%, Average air transport time was 31 ± 12.3 (SD) min. For prediction of MT, the AUC for BRI (solid red line) was 0.94 (CI: 0.91-0.96), significantly better than ABC (AUC=0.80, CI: 0.73-0.87), SI (AUC=0.83, CI:0.76-0.90) and RTS (AUC=0.78, CI: 0.71-0.85). For predicting CAT, BRI (AUC=0.95, CI: 0.93-0.96) was also significantly better than ABC (AUC=0.78, CI: 0.73-0.82), SI (AUC=0.85, CI:0.80-0.89) and RTS (AUC=0.79, CI: 0.74-0.83).

Conclusion: The continuous non-invasive patient vital signs-based BRI score performs better than ABC, RTS and SI predictions of emergency and massive transfusion. BRI does not require additional or expert interpretation of data. Automated prediction of transfusion using machine learning and artificial intelligence may better assist blood-bank planning and pre hospital triage decision-making, especially in situations of prolonged field care or where medical expertise may not be immediately available.

[1]: Cotton BA, et. al. Journal of Trauma and Acute Care Surgery. 2010 Jul 1;69(1):S33-9.

Supported in part by FA8650-17-2-6H09 ONPOINT3 and W81XWH-17-C-0034 ONPOINT6

TRANSFUSION OF A SINGLE "DISCRETIONARY" UNIT OF RED BLOOD CELLS IS ASSOCIATED WITH WORSE CLINICAL OUTCOMES IN TRAUMA PATIENTS: A TRAUMA QUALITY IMPROVEMENT PROGRAM (TQIP) STUDY

Khaled Abdul Jawad MD, Daniel D. Yeh MD, Roman Dudaryk MD, Charlie Nederpelt BS, Mohamad El Moheb MD, Haytham Kaafarani MD, MPH, Alessia Cioci MD, Eva Urrechaga MD, Saskya E Byerly MD, MSc, Rishi Rattan MD, Gerd D. Pust MD, Nicholas Namias MD, MBA, Richard Epstein MD
University of Miami Miller School of Medicine

Invited Discussant: Jeffrey Kerby, MD, PhD

Introduction: Studies in elective surgery report adverse outcomes associated with transfusion of a solitary ("discretionary") unit of red blood cells (RBC) compared to no transfusion. We explored if a similar association exists in trauma patients.

Methods: The 2017 Trauma Quality Improvement Program (TQIP) database was queried for adults (≥18 years) with blunt/penetrating trauma, Glasgow Coma Scale (GCS)>8, and Injury Severity Score (ISS) 9-25. Patients with severe brain injury, mild injury, or severe injury were excluded. Random matching without replacement was conducted between those who received 1 unit of RBCs in the first 4 hours with no subsequent blood product transfusions and those who received no blood products during the entire hospitalization. Matching was performed at a ratio of up to 1:10 based on: age (≤65/>65 years), injury mechanism (blunt/penetrating), ISS (moderate/severe), GCS (mild/moderate), arrival systolic blood pressure (120). Relative risks (RR) of infections (superficial, deep, or sepsis), deep vein thrombosis (DVT) or pulmonary embolus (PE), and inpatient mortality were compared. P-values were adjusted according to Holm-Bonferroni for multiple comparisons.

Results: A total of 1238 transfused patients were matched to 11966 controls (mean ratio 1:9.7). Among transfused, the median age was 45.5 years (IQR 30,64), and 67.8% were male. Hypotension, tachycardia, or both were present in 11.8%, 13.5%, and 1.5% patients respectively. Blunt trauma occurred in 70.2%, brain injury was mild in 93.8%, and ISS was moderate in 45.3%. Comparing transfused to control, there were statistically significant, clinically relevant increased RRs of infection (3.27), DVT/PE (2.18), and mortality (1.8)**(Table).**

Conclusion: Compared to no transfusion, transfusion of a single unit of RBCs in the first 4 hours in trauma patients who did not require any subsequent units during hospitalization was associated with clinically significant increased risks of infection, DVT or PE, and mortality. Additional research is required to compare the risk/benefit of transfusion of a discretionary unit vs modest crystalloid challenge and the potential confounding effect of trauma center on outcomes. Unfortunately, the TQIP database does not provide identifiers for trauma centers.

Adverse Outcome	Transfused 1 Unit (n=1238)	Not Transfused (n=11966)	Relative Risk (95% CI)	P-value
Tissue Infection	24 (1.9%)	71 (0.6%)	3.27 (2.06, 5.17)	<.001
Deep Vein Thrombosis or Pulmonary Embolus	30 (2.4%)	133 (1.1%)	2.18 (1.47, 3.23)	<.001
Mortality	40 (3.2%)	215 (1.8%)	1.8 (1.29, 2.51)	<.001

Table: Relative Risks of Adverse Outcomes in the Transfused Group Compared to the Control Group

Session VIII: Plenary Papers 45-51
Paper 48: 5:00 PM - 5:20 PM

CLAMSHELL THORACOTOMY BETTER FACILITATES THORACIC LIFE-SAVING PROCEDURES WITHOUT INCREASED COMPLICATIONS COMPARED TO ANTEROLATERAL APPROACH TO RESUSCITATIVE THORACOTOMY: RESULTS FROM THE AAST AORTA REGISTRY

Joseph J. DuBose MD, Jonathan Morrison MD, PhD, Laura J. Moore MD, Jeremy W. Cannon MD, Mark J. Seamon MD, Kenji Inaba MD, Charles J. Fox MD, Ernest E. Moore MD, David V. Feliciano MD, Thomas M. Scalea MD
Uniformed Services University of the Health Sciences

Invited Discussant: Elizabeth Benjamin, MD, PhD

Introduction: Resuscitative thoracotomy (RT) is life-saving in select patients and can be accomplished through a left anterolateral (AT) or clamshell thoracotomy (CT). CT may provide additional exposure facilitating certain operative procedures but the added blood and heat loss and time to perform it may increase complications. No prospective multicenter comparison of techniques has yet been reported.

Methods: The observational AAST Aortic occlusion for resuscitation in trauma and acute care surgery (AORTA) registry was used to compare AT and CT in RT.

Results: AORTA recorded 1,218 RTs at 46 trauma centers from Jun 2014 – Jan 2020. Overall survival following RT was 6.0% (AT 6.6%; [59/900]; CT 4.2% [13/296], p = 0.132). Among all RTs, 11.1% (142/1278) surviving at least 24 hours were utilized to compare AT (112) and CT (30). There was no difference between the two groups with regards to age, gender, ISS or mechanism of injury [Table]. CT was significantly more likely to be used in patients needing lung resection and cardiac repair. CT was not associated with increased local thoracic / systemic complications, higher transfusion requirement, or greater ventilator, ICU or hospital days compared to AT.

Conclusion: Clamshell thoracotomy facilitates thoracic life-saving procedures without increased systemic or thoracic complications compared to AT in patients undergoing RT.

	Total (N = 142)	Anterolateral (N = 112)	Clamshell (N = 30)	p - value
Mean age (+/- SD)	35.8 +/- 15.3	32.2 +/- 14.8	35.8 +/- 12.7	p = 0.191
Male, % (n/N)	78.2% (111/142)	76.8% (86/112)	83.3% (25/30)	p = 0.441
ISS ≥ 20, % (n/N)	76.2% (96/126)	74.5% (76/102)	83.3% (20/30)	p = 0.361
Penetrating, % (n/N)	64.1% (91/142)	60.7% (68/112)	76.7% (23/30)	p = 0.106
Chest AIS ≥ 3, % (n/N)	77.8% (84/108)	73.2% (63/86)	95.5% (21/22)	p = 0.024
Lung resection, % (n/N)	14.8% (21/142)	9.8% (11/112)	33.3% (10/30)	p = 0.003
Cardiac repair, % (n/N)	9.2% (13/142)	5.4% (6/112)	23.3% (7/30)	p = 0.007
OUTCOMES				
ALI/ARDS, % (n/N)	16.9% (24/142)	17.9% (20/112)	13.3% (4/30)	p = 0.557
Pneumonia, % (n/N)	20.4% (29/142)	21.4% (24/112)	16.7% (5/30)	p = 0.566
Retained hemothorax, % (n/N)	6.3% (9/142)	6.3% (7/112)	6.7% (2/30)	p = 1.000
Empyema, % (n/N)	4.2% (6/142)	3.6% (4/112)	6.7% (2/30)	p = 0.607
Mean PRBCs 24hours (+/- SD)	21.4 +/- 18.3	20.6 +/- 17.1	24.4 +/- 22.4	p = 0.321
Mean ventilator days (+/- SD)	9.8 +/- 10.1	13.9 +/- 19.6	9.2 +/- 10.3	p = 0.237
Mean ICU LOS (+/- SD)	11.7 +/- 11.7	9.2 +/- 10.3	13.5 +/- 15.3	p = 0.546
Hospital LOS (+/- SD)	18.1 +/- 18.5	19.6 +/- 22.1	17.5 +/- 19.4	p = 0.627
Survival to discharge, % (n/N)	47.9% (68/142)	50.0% (56/112)	40.0% (12/30	p = 0.330

Session VIII: Plenary Papers 45-51
Paper 49: 5:20 PM - 5:40 PM

LONG-TERM OUTCOMES OF ILLICIT DRUG USE IN TRAUMA PATIENTS: A MULTICENTER PATIENT-REPORTED OUTCOMES STUDY

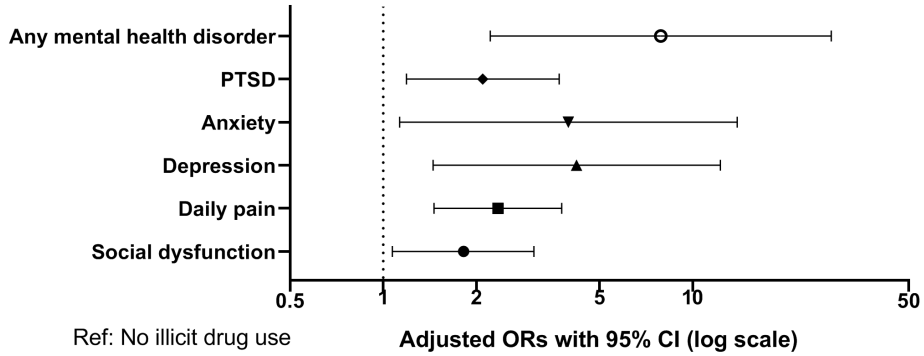
Mohamad El Moheb MD, Juan Herrera-Escobar MD, MPH, Kerry Breen BS, Claudia Orlas MD, Ashley Haynes BS, Nomi Levy-Carrick MD, Deepika Nehra MD, Sabrina Sanchez MD, Ali Salim MD, George Velmahos MD, PhD, Haytham Kaafarani MD, MPH
Massachusetts General Hospital

Invited Discussant: Michael Lekawa, MD

Introduction: Illicit drug use (IDU) is reported in up to 40% of trauma patients and is associated with a higher rate of in-hospital complications. However, little is known about its long-term impact on trauma patients. We aimed to assess the long-term mental and psychosocial outcomes of IDU in trauma patients 6-12 months after injury.

Methods: Trauma patients with moderate to severe injuries (ISS $\geq$ 9) who had a toxicology screen upon admission to one of three level 1 trauma centers were contacted by phone 6-12 months post-injury. IDU was defined as the presence of an illicit, non-prescribed substance on toxicology screen. The interviews systematically evaluated mental health (PTSD, depression, anxiety), chronic pain, and social functioning (SF-12 sub-domain). Patients with a score of 47 or lower on the SF-12 social functioning sub-domain were considered to have social dysfunction. Demographics, socioeconomic parameters, injury characteristics and hospital course data were also collected. Multivariable logistic regression models were built to determine the independent association between a positive screening for IDU at admission and long-term mental and psychosocial outcomes.

Results: A total of 571 patients were included in the analysis, of whom 173 (30.3%) screened positive for IDU on admission. IDU patients were younger (median age: 43 [28,55] vs 66 [46, 78], P < 0.001), had more penetrating injuries (8.7% vs 4.3%, P = 0.036), and were less likely to have received a college education (41.3% vs 54.5%, P = 0.004). After adjusting for patients' characteristics including the presence of a baseline psychiatric comorbidity, IDU patients were 8 times more likely to screen positive for a mental health disorder after injury. They were also more likely to screen positive for each of the individual mental health disorders: PTSD, depression, and anxiety. Additionally, they were twice as likely to suffer from daily chronic pain and social dysfunction 6-12 months after injury (**Figure**).



Conclusion: On the long term, IDU in trauma patients is strongly and independently associated with worse mental health, more chronic pain and severe impairment in social functioning. A trauma hospitalization presents an opportunity to screen and identify patients at risk and to mitigate the long-term impact of IDU.

MODIFIABLE FACTORS TO IMPROVE WORK-LIFE BALANCE FOR TRAUMA SURGEONS

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Invited Discussant: Jamie Coleman, MD

Introduction: A balance between work, and life outside of work, can be difficult for trauma surgeons to achieve. The specific aim of this study was to investigate factors associated with WLB for trauma surgeons. We hypothesized that trauma surgeons are dissatisfied with their WLB and there are modifiable factors that can be adjusted to improve and maintain WLB.

Methods: This was a survey study of AAST members involving detailed questions regarding demographics, clinical practice, family, lifestyle, and emotional support. The primary outcome was WLB while the secondary outcome was surgeon burnout.

Results: A total of 1,383 AAST members received an email with the survey, and 291 (21%) completed the survey. There was a total of 125 members (43%) satisfied with their WLB, while 166 (57%) were not. When comparing those who were satisfied with WLB to those who were not, there was no difference in age (51 vs. 49, p=.14), male gender (74% vs. 69%, p=0.36), or type of practice (p=0.19). Trauma surgeons satisfied WLB were more likely to be early (< 10 years) or late (> 20 years) career (p=0.02), spend fewer hours at work (p=0.004), more hours awake at home (p=0.001), enjoy their current job (p < 0.0001) and partners (0.0003), be better at saying no to (p=0.0004) and delegating (p=0.006) work-related tasks, and feel fairly compensated (p < 0.0001). Trauma surgeons satisfied with WLB more often participate in hobbies (86% vs. 68%, p=0.004), exercise (49% vs. 20%, p < 0.0001), have a healthy diet (74% vs. 48%, p < 0.0001), and get more hours of sleep at night (7 vs. 6, p=0.0004). In addition, despite receiving the same allotment of vacation weeks (4 vs. 4, p=0.47), the satisfied WLB group actually took more vacation weeks (4 vs. 3, p=0.005). Emotional support was better at work (73% vs. 47%, p < 0.0001) and home (95% vs. 83%, p=0.002) for those satisfied with WLB. After logistic regression, several factors were independently associated with WLB (see table). Those NOT satisfied with WLB self-reported suffering burnout (77% vs. 39%, p < 0.0001. Burnout shared several factors with those NOT satisfied with WLB including being mid-career [2.1(1.1-4.2, p=0.03], more hours at work [2.4 (1.2-4.9, p=0.02], fewer awake hours at home [3.3 (1.3-8.3, p=0.009], and feeling there is a better job for yourself [2.4 (1.2-4.8, p=0.02].

Satisfied WLB	OR (95% CI)	p-value	**NOT Satisfied WLB**	OR (95% CI)	p-value
Hobbies	2.3 (1.1-4.7)	0.03	Mid-Career (11-20 years)	0.3 (0.2-0.7)	0.002
Diet	2.6 (1.2-4.4)	0.02	More work hours	0.4 (0.2-0.7)	0.006
Exercise	2.6 (1.3-5.1)	0.006	Fewer home hours	0.2 (0.1-0.6)	0.002
Vacation weeks	1.3 (1.0-1.6)	0.02	Feel there is better job	0.4 (0.2-0.9)	0.02
Fair compensation	2.6 (1.3-5.3)	0.008			

Conclusions: Almost 60% of trauma surgeons surveyed were not satisfied with their WLB. Modifiable factors independently associated with a satisfying WLB were related to lifestyle and fair compensation. Factors independently associated with poor WLB and suffering burnout were being mid-career, increased hours at work, decreased awake hours at home, and feeling there was a better job for yourself. Factors associated with trauma surgeon WLB are modifiable. Trauma surgeons, as well as trauma leaders, should focus on these modifiable factors to optimize WLB and minimize burnout.

Session VIII: Plenary Papers 45-51
Paper 51: 6:00 PM - 6:20 PM

RECTAL DELIVERY OF OXYGEN MICROBUBBLES AUGMENTS SYSTEMIC OXYGENATION IN PORCINE MODEL OF SMOKE INHALATION-INDUCED ACUTE RESPIRATORY DISTRESS SYNDROME

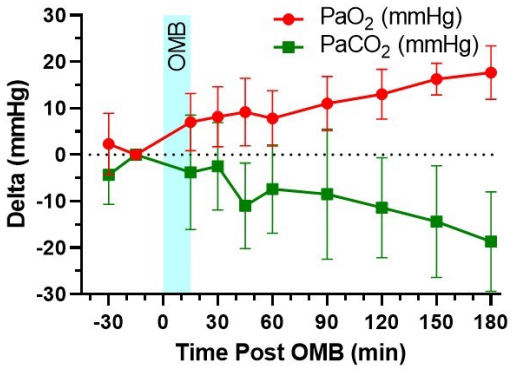
Paul Mountford PhD, Premila Leiphrakpam PhD, Hannah Weber, Andrea McCain,
Roser Romaguera Matas PhD, Nathaniel Zollinger BS, Benjamin Terry PhD, Mark Borden PhD,
Robert Scribner MBA, **Keely Buesing MD**
University of Nebraska Medical Center

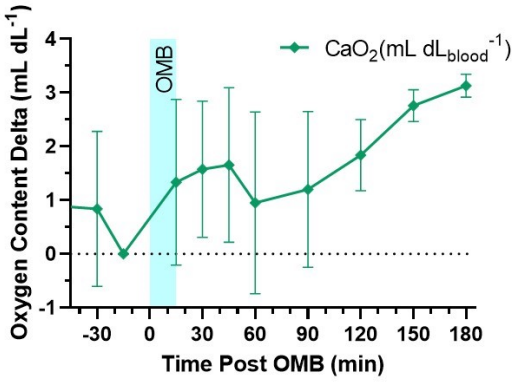
Invited Discussant: George Kasotakis, MD, MPH

Introduction: Acute respiratory distress syndrome (ARDS) is multifactorial and can result from sepsis, trauma, or pneumonia, as well as other primary pathology. It is one of the major causes of death in critically ill patients with a reported mortality rate of up to 60%. Oxygen microbubbles (OMB) are a novel therapy under investigation by our multi-campus, interdisciplinary research teams. In previous studies, we have shown that OMB treatment augments systemic oxygenation via diffusion across cavitary membranes. The present study focuses on the effect of OMB infusion via the colon in a porcine model of smoke inhalation-induced ARDS.

Methods: Animals (n = 6, ranging from 39-51 kg in weight) were exposed to smoke under general anesthesia for 2 hours (median smoke exposure = 1000 L oak wood smoke) after the ultrasound-guided placement of carotid, pulmonary, and femoral artery catheters. Peripheral oxygen saturation (SpO_2), vital signs, and ventilator parameters were monitored throughout the procedure. Chest x-ray, arterial, femoral and pulmonary artery blood samples were collected throughout the study. After the development of ARDS (48 hours post smoke inhalation), animals were maintained on minimal ventilator settings with FiO_2 = 21%. After three consecutive hypoxic blood gas measurements ($PaO_2 \leq 45$ +/- 5 mmHg) at 5 minute intervals, animals were given a one-time bolus treatment of OMB via the colon (dose volume of 3.6-4.3 L) and monitored for treatment effect. Animals were euthanized and lung tissue collected for analysis at the end of the study.

Results: Animals developed ARDS 48 hours after smoke inhalation as reflected by a SpO_2 of 60-85%, a PaO_2 of 31-46 mmHg and a CaO_2 of 4.6-8 mL dL_{blood}^{-1}, and bilateral, diffuse infiltrates demonstrated on CXR. OMB treatment resulted in significant improvements in systemic oxygenation as demonstrated by an increase in PaO_2 of 11-21 mmHg and CaO_2 of 1.3-3.3 mL dL_{blood}^{-1} and a decrease in $PaCO_2$ of 6.3-24.9 mmHg, along with improvements in other ABG parameters over a 3 hour post-treatment monitoring period.





	Before	After	Significance
PaO_2 (mmHg)	40.2 ± 5.2	56.2 ± 6.7	**
$PaCO_2$ (mmHg)	73.2 ± 8.0	54.1 ± 5.3	*
CaO_2 (mL/dL)	5.9 ± 1.2	8.9 ± 1.4	***

Conclusions: This study reports, for the first time, the successful augmentation of systemic oxygenation following colonic OMB treatment in a large animal model of smoke inhalation-induced ARDS. We propose OMB therapy as a novel treatment modality with great translational potential for oxygenation support in patients with ARDS.

ALIVE AND AT HOME: 5-YEAR OUTCOMES IN OLDER ADULTS FOLLOWING EMERGENCY GENERAL SURGERY

Matthew Guttman MD, Bourke Tillmann MD, Avery B. Nathens MD, PhD, MPH, Refik Saskin MSc, Susan Bronskill PhD, Anjie Huang MSc, Barbara Haas MD, PhD
University of Toronto

Invited Discussant: Zara Cooper, MD, MSc

Background: Older adults (age > 65) represent 40% of hospitalizations for emergency general surgery (EGS) conditions, and this proportion will rise significantly over the next decade. While the short-term risks of EGS admission among older adults are well studied, little is known about long-term outcomes in this patient population. Moreover, data regarding long-term function and maintenance of autonomy following EGS admission among older adults are lacking. Accurate estimates of these risks are critical to patient counselling, selection of patients who might benefit from surgery, and the development of quality improvement initiatives. The objective of this study was to evaluate the relationship between EGS admission and the probability of an older adult being alive and living in their own home 5 years later. In addition, we evaluated the extent to which specific EGS diagnoses, need for operative intervention, and frailty modified this relationship.

Methods: We performed a population-based, retrospective cohort study of community dwelling older adults (age ≥ 65) admitted to hospital for 1 of 8 EGS diagnoses (appendicitis, cholecystitis, strangulated hernia, bowel obstruction, diverticulitis, peptic ulcer disease, intestinal ischemia, or perforated viscus) between 2006-2018 in a large regional health system. The primary outcome of interest was time spent alive and at home following an EGS-related admission (measured as time to nursing home admission or death). To ascertain the effect of EGS admission on being alive and at home independent of baseline characteristics, patients were matched to controls from the general population based on demographics and indicators of baseline health. Kaplan-Meier analysis was used to evaluate differences in mean time spent alive and at home across groups. Cox proportional hazard models were used to evaluate the risk of nursing home admission or death across time among cases compared to controls. All analyses were stratified by diagnosis, operative status and frailty.

Results: A total of 90,245 older adults admitted with an EGS diagnosis were identified and matched with controls. Mean patient age was 77.2 (±7.2) years, 54.3% were female and 10.4% were frail. Forty-one percent of patients underwent surgery during their admission. In the 5 years following their EGS admission, cases experienced significantly fewer months alive and at home compared to controls (mean time 43 vs. 50 months, $p < 0.001$). This association held in patients with frailty, whose mean time alive and at home was 28 months (controls 35 months, $p < 0.001$). In subgroup analyses, patients operated on for appendicitis or cholecystitis had long-term outcomes equivalent to controls. However, all other patient subgroups, regardless of diagnosis, operative status or frailty, experienced reduced time alive and at home compared to controls ($p < 0.001$). Cases had a 5-fold increased risk of nursing home admission or death in the first 3 months post-admission (HR 5.11, 95% CI 4.89-5.35). While the risk of nursing home admission or death decreased over time, patients who had experienced an EGS admission remained at elevated risk compared to controls for the entirety of the 5 year follow up (years 2-5, HR 1.17, 95% CI 1.15-1.19).

Conclusion: Older adults who require hospitalization for an EGS diagnosis are at increased risk for death or admission to a nursing home for at least 5 years following admission. However, most patients remain alive and living in their own home for several years following admission. Future work should focus on designing structures and processes of care to decrease the long-term risks experienced by patients discharged home following an EGS admission.

FAST TRACK PATHWAY PROVIDES SAFE, VALUE BASED CARE ON BUSY ACUTE CARE SURGERY SERVICE

Kali M. Kuhlenschmidt MD, Erika K. Bisgaard MD, Natasha Housmand BS, Paul Comish MD, MPH, Stephen S. Luk MD, Joseph P. Minei MD, MBA, Michael W. Cripps MD
UT Southwestern

Invited Discussant: Lillian Kao, MD, MS

Background: Fast track (FT) pathways have been adopted across a multitude of elective services, while being slow to be adopted into the acute care surgery (ACS) realm. We hypothesized that a FT pathway implemented in an ACS service would safely decrease patient length of stay and resource utilization. To minimize variation we selected a singular, common operation, cholecystectomy, compared across two hospitals with well-established ACS services, differing only in the presence of a FT pathway.

Methods: Patients that underwent an urgent or emergent laparoscopic cholecystectomy for acute cholecystitis between May 1 and October 31, 2019 were queried using CPT codes. Patients that required a conversion to open or partial cholecystectomy were excluded as they no longer qualified for the fast track pathway. Retrospective chart review was used to gather information relating to the patients demographics, presentation, hospital course, and outcomes. Hospital length of stay and resource utilization were the primary outcomes.

Results: There was a total of 479 urgent or emergent laparoscopic cholecystectomies performed during the 6 months for acute cholecystitis. Four hundred and thirty (89.8%) were performed under the FT pathway. The median time to the OR following surgical consultation was not different between the two pathways (p=0.316), however, the median length of stay (hours [IQR]) was shorter by 15.9 hours in the FT cohort (22.6 [14.2-40.4] vs 38.5 [28.3-56.3], $p < 0.0001$). Under the FT pathway, only 33% of patients were admitted to the hospital and 75.6% were discharged from the PACU, as compared to 91.8% and 12.2% on the traditional pathway, respectively (both $p < 0.0001$). 59.6% of FT patients received a phone call follow up, as opposed to the traditional pathway where all patients had clinic follow up ($p < 0.0001$). ED bounce back rates, readmission rates, and complication rates were similar between the FT and traditional pathways ($p > 0.2$ for all). On multivariate analysis, fast track pathway patients were 7.65 times more likely to be discharged within 24 hours of surgical consultation (table)**.**

Conclusion: Use of a fast track program for patients with acute cholecystitis results in shorter times in the hospital, less inpatient bed usage and fewer clinic appointments benefiting the hospital, surgeon and patient, without compromise of clinical outcomes. Incorporation of a FT pathway into all areas of ACS should be investigated.

Multivariate logistic regression predicting discharge from hospital within 24 hours of consult

Variable	OR	95% CI	*p*-value
Age (per year)	1.00	0.98 - 1.01	0.481
Female gender	1.01	0.63 - 1.63	0.961
Race and ethnicity	0.83	0.54 - 1.29	0.411
Presence of comorbidities	0.51	0.32 – 0.83	0.006
Operative Time (per minutes)	0.99	0.98 - 0.99	<0.0001
Fast Track	7.65	2.90 - 20.15	<0.0001

Session IX: Plenary Papers 52-59
Paper 54: 12:40 PM - 1:00 PM

WHAT HAPPENS WHEN THEY'RE GONE? THE IMPACT ON HOSPITAL REVENUE AND OPERATIVE CASELOADS WHEN EMERGENCY GENERAL SURGERY OPERATIONS ARE REGIONALIZED

Robert D. Becher MD, Nitin Sukumar, Thomas Gill MD, Kevin M. Schuster MD, MPH, Adrian A. Maung M.D., Michael DeWane MD, Kimberly A. Davis MD, MBA
Yale School of Medicine

Invited Discussant: Jennifer Knight, MD

Introduction: The American College of Surgeons has advocated for the integration of surgical care delivery across geographic areas. Within the field of emergency general surgery (EGS), such a structured system of care has been shown to potentially reduce mortality. However, the possible benefit to patients may be a detriment to hospitals and surgeons. The aim of this study was to determine the financial and operative impact to institutions that would stop performing EGS operations due to regionalization.

Methods: Adult patients who underwent one of ten common EGS operations (see Table) were identified in the California State Inpatient Database (2010-2011). Building on our prior regionalization-simulation work, we identified all acute care hospitals which would be "closed" (meaning stop performing ≥1 EGS operation type) due to the hospital's higher EGS mortality. At these institutions, we calculated operative volumes as well as hospitalization costs across multiple cohorts: EGS-specific; all general surgery; all major surgery (across surgical disciplines); and all hospital discharges. Given the difference between what a hospital charges and the actual costs to the hospital, an institution-specific standardized conversion ratio was applied to calculate costs, which were used as a surrogate for revenue. Operative and financial data were then compared pre- and post-regionalization.

Results: A mean of 119 hospitals were "closed," and an average of 14 patients were regionalized, for each EGS operation at each hospital over 2 years (see Table). The weighted-average in lost hospital revenues were $34,823 per patient and $487,881 per hospital (see Table). After EGS regionalization, a significant proportion (>95%; p< 0.001) of a given hospital's mean general surgery operative volume remained intact, as did >98% (p< 0.001) of overall major surgery caseloads. In financial terms, a significant proportion of general surgery hospital revenue (>94%; p< 0.001), of major surgery hospital revenues (>97%; p< 0.001), and of overall hospital discharge revenues (>99%; p< 0.001) also remained intact. When regionalizing only a group of the four highest-mortality operations (mortality >10%; see *Table), operative volumes and hospital revenues at the 60 impacted institutions were not significantly affected.

Operation Type (mean mortality rate)	Hospitals "closed"	Mean EGS volume lost, per hospital	Mean EGS revenue lost, per patient	Mean EGS revenue lost, per hospital
Appendectomy (0.9%)	68	34	$13,117	$440,606
Cholecystectomy (1.5%)	73	36	$19,083	$687,743
Colectomy (12.4%)*	181	22	$55,403	$1,237,155
Inguinal & Femoral Hernia (6.8%)	81	5	$13,858	$73,446
Lysis of Adhesions (7.1%)	108	10	$31,301	$312,692
NSTI Excision (13.2%)*	109	6	$43,351	$261,838
Repair of Perforated PUD (17.8%)*	169	7	$44,169	$287,542
Small Bowel Resection (12.1%)*	188	16	$47,283	$749,437
Umbilical Hernia (9.7%)	103	4	$14,456	$63,174
Ventral Hernia (7.1%)	110	6	$18,688	$111,196

Conclusions: This study suggests that EGS regionalization may be financially and operatively viable with fewer negative repercussions to "closed" hospitals than generally assumed. The loss of EGS operative volume would have little impact on surgery caseloads. Financially, hospital revenue would not decrease significantly from pre-regionalization levels. Losses to case volume may be offset by increasing elective operative volumes.

Session IX: Plenary Papers 52-59
Paper 55: 1:00 PM - 1:20 PM

MULTICENTER VALIDATION OF THE AAST GRADING SCALE FOR ACUTE CHOLECYSTITIS

Kevin M. Schuster MD, MPH, Michael W. Cripps MD, Kali M. Kuhlenschmidt MD, Luis Taveras MD, Haytham Kaafarani MD, MPH, Majed El Hechi MD, Daniel Cullinane MD, Toby M. Enniss MD, Thomas J. Schroeppel MD, Jennifer Rodriquez, Ruchir Puri MD, Jennifer Mull, Rachel Sensenig MD, Brian Zilberman MD, Marie L. Crandall MD, MPH
Yale School of Medicine

Invited Discussant: Eric Toschlog, MD

Introduction: The AAST patient assessment committee has created grading systems for emergency general surgery diseases to assist with clinical decision making and risk adjustment during research. Single institution studies have validated the cholecystitis grading system as associated with patient outcomes. Our aim was to validate the grading system in a multi-institutional fashion and compare it to the Parkland grade for acute cholecystitis.

Methods: Patients presenting with acute cholecystitis to one of 8 institutions were enrolled. Discrete data to assign the AAST grade were collected. The Parkland grade was collected prospectively from the operative surgeon from four institutions. Parkland grade, AAST grade, and the imaging and operative subscales of the AAST grade were compared using linear and logistic regression to the need for surgical "bail-out" (sub-total or fenestrated cholecystectomy, conversion to open or cholecystostomy), surgical complications (bile leak, surgical site infection, bile duct injury) discharge disposition, all complications and OR time.

Results: Of 861 patients 781 underwent cholecystectomy. Mean age was 51.1 (18.6) and 62.7% were female. There were 6 deaths. Median AAST grade was 2 (IQR 1-2) and median Parkland grade was 3 (IQR 2-4). Median AAST clinical and imaging grades were 2 (IQR 2-2) and 1 (IQR 0-1) respectively. Higher grades were associated with longer operative times and worse outcomes though few were significant (Table). The Parkland grade outperformed the AAST grade based on area under the receiver operating characteristic curve (AROC)

	Any surgical "bail-out" OR (95% CI)	Surgical complication OR (95% CI)	Discharge other than home. OR (95% CI)	Any complication OR (95% CI)	OR time mins (sd)
AAST grade (AROC)	0.608	0.579	0.573	0.599	p< 0.001
Grade I	Reference	Reference	Reference	Reference	98.1 (53.9)
Grade II	1.55 (0.77 – 3.10)	1.26 (0.51 – 3.13)	0.95 (0.50 – 1.77)	1.53 (0.89 – 2.65)	108.9 (6.21)
Grade III	6.46 (2.37 – 17.61)	4.33 (1.27 – 14.57)	3.89 (1.55 – 9.78)	5.39 (2.37 – 12.29)	147.3 (68.9)
Grade IV	3.37 (0.99 – 11.44)	1.34 (0.21 – 8.64)	2.59 (0.91 – 7.44)	3.67 (1.47 – 9.11)	129.1 (56.6)
Grade V	19.36 (1.13 – 330.52)	4.02 (0.09 – 179.80)	2.12 (0.07 – 67.62)	1.75 (0.06 – 55.60)	121.1 (1.4)
AAST imaging grade (AROC)	0.535	0.559	0.547	0.550	p=0.078
Grade I	Reference	Reference	Reference	Reference	111.5 (57.6)
Grade II	1.51 (0.33 – 6.817)	0.51 (0.03 – 9.44)	1.63 (0.40 – 6.61)	0.68 (0.12 – 3.83)	132.3 (52.6)
Grade III	3.25 (1.02 – 10.42)	4.03 (1.14 – 14.24)	3.20 (1.16 – 8.86)	2.93 (1.13 – 7.64)	145.3 (78.8)
Grade IV	1.18 (0.15 – 9.50)	0.80 (0.04 – 15.99)	2.60 (0.75 – 8.96)	0.23 (0.01 – 4.12)	101.0 (25.2)
Grade V	No patients	No patients	No patients	No patients	No patients
AAST Operative grade (AROC)	0.646	0.587	0.641	0.564	p<0.001
Grade I	Reference	Reference	Reference	Reference	103.2 (61.9)
Grade II	2.74 (1.52 – 4.93)	1.72 (0.84 – 3.53)	3.24 (1.28 – 8.16)	1.50 (0.85 – 2.64)	124.4 (53.6)
Grade III	6.18 (2.14 – 17.82)	5.70 (1.83 – 17.76)	7.33 (1.66 – 32.35)	4.80 (1.78 – 12.95)	142.5 (53.2)
Grade IV	24.38 (3.97 – 149.54)	6.96 (0.89 – 54.71)	4.93 (0.20 – 124.61)	3.57 (0.46 – 27.62)	169.6 (47.7)
Grade V	52.16 (0.56 - >999)	6.93 (0.07 – 654.68)	17.99 (0.19 - >999)	3.55 (0.04 – 333.5)	120.0
Parkland grade (AROC)	0.816	0.726	0.684	0.711	p<0.001
Grade I	Reference	Reference	Reference	Reference	68.5 (20.5)
Grade II	.039 (0.01 – 20.59)	1.97 (0.09 – 43.73)	1.17 (0.05 – 30.54)	0.91 (0.13 – 6.52)	78.7 (32.4)
Grade III	2.18 (0.11 – 43.04)	1.69 (0.08 – 34.65)	0.71 (0.03 – 18.52)	0.87 (0.14 – 5.62)	102.2 (73.5)
Grade IV	14.02 (0.78 – 251.03)	8.62 (0.47 – 158.03)	1.24 (0.05 – 32.28)	5.31 (0.93 – 30.32)	123.6 (57.7)
Grade V	23.63 (1.34 – 416.53)	9.41 (0.52 – 171.35)	2.89 (0.14 – 59.52)	3.72 (0.64 – 21.67)	136.1 (77.9)

Table 1: Odds ratios and 95% confidence intervals (OR 95% CI) for outcomes based on AAST grade, imaging grade, operative grade and Parkland grade. Operating room times for each grading scale as mean (sd-standard deviation) AROC – Area under Receiver Operating Characteristic Curve

Conclusions: The AAST cholecystitis grading schema has modest discriminatory power and should be modified before widespread use.

Session IX: Plenary Papers 52-59
Paper 56: 1:20 PM - 1:40 PM

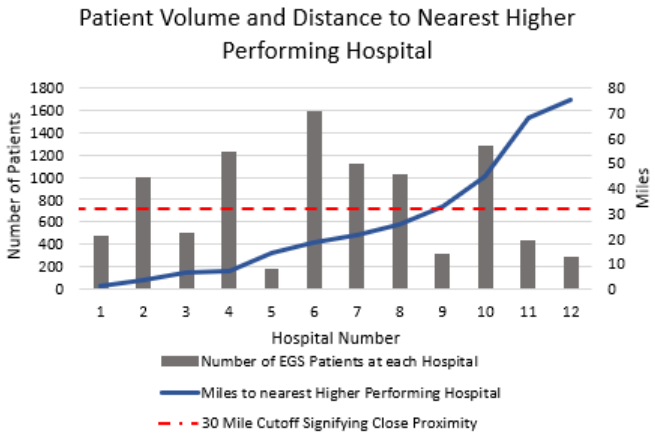
WILL TRAUMA SYSTEMS WORK FOR EGS? QUANTIFYING GEOGRAPHIC PROXIMITY BETWEEN LOWER AND HIGHER PERFORMING EMERGENCY GENERAL SURGERY HOSPITALS

Michael DeWane MD, Nitin Sukumar, Kevin M. Schuster MD, MPH, Adrian A. Maung MD, Kimberly A. Davis MD, MBA, Robert D. Becher MD
Yale Department of Surgery

Invited Discussant: Avery Nathens, MD, PhD, MPH

Introduction: Given the high morbidity and mortality associated with emergency general surgery (EGS), developing integrated local networks of EGS care may be beneficial. However, it is unknown whether geographic relationships between hospitals performing EGS operations affect outcomes. To better understand this issue, our study aimed to quantify: 1) the distance between the lowest-performing EGS hospitals and their nearest higher-performing EGS hospital; and 2) the distance from the lowest-performing EGS hospitals to their nearest Level I or II Trauma Center.

Methods: Adults undergoing 1 of 8 common EGS operations were identified in the California State Inpatient Database (2010-2011), which was paired with the American Hospital Association survey. Hospital-based risk-adjusted standardized mortality ratios based on a prior study were used to stratify hospitals by 3-tiers: poor-performing outliers, average performers, and high-performing outliers. Geographic modeling was used to calculate geodesic straight-line distance from the poor-performing outliers to nearest average or high-performing outlier hospital and nearest Level I or II trauma center.



Results: 217 acute care hospitals were analyzed. 12 hospitals were identified as poor-outliers (see Figure); total EGS cases performed per hospital (bar height) and distance to the nearest higher performing hospital (continuous line) are shown. Median distance to a higher performing hospital was only 20.1 miles (range 1.1-75.3 miles). For 8/12 poor-outlier hospitals performing 7,095 EGS operations over 2 years, a higher-performing center was located within 30 miles (dashed line). Median distance from the poor-outliers to the nearest level I or II trauma center was 48.3 miles; only 4 were located within 30 miles.

Conclusion: The lowest-performing EGS hospitals in California are, on average, located in close proximity to higher-performing EGS institutions. Thousands of EGS patients are operated on at poor-outlier hospitals within just 30 miles of a significantly higher-quality EGS institution. Only 33% of poor-outliers are located near a certified trauma center. As such, existing transfer networks for trauma may not be sufficient for EGS, especially for critically ill patients. Coordination of EGS care across novel networks of hospitals, starting within small geographic areas, may improve outcomes at a systems level.

Session IX: Plenary Papers 52-59
Paper 57: 1:40 PM - 2:00 PM

TRAUMA HEALTH LITERACY: STEPS TOWARD REMEDIATION

Catherine P. Seger MD, Emily Lenart DO, Dina Filiberto MD, Staci Martinez, Richard Lewis MD, Martin A. Croce MD, Louis J. Magnotti MD, MSc
UTHSC Memphis

Invited Discussant: Cherisse Berry, MD

Introduction: Health literacy in trauma patients remains sorely lacking. In a previous study at our institution, less than half of the patients correctly recalled either their injuries or operations post-discharge. Consequently, a simple vernacular discharge information form was developed as part of a quality improvement (QI) project. The purpose of the current study was to evaluate the impact of this form on the injury specific health literacy of these patients. Specifically, we hypothesized that the addition of this simple form would improve patients' knowledge of both their injuries and operative procedures.

Methods: Consecutive patients at a Level 1 trauma center were evaluated prospectively prior to and post-introduction of a discharge information form. All patients discharged following implementation of the QI project received the form. Patients were then surveyed at their first follow-up visit post-discharge (within a 4-month period) for knowledge of their injuries, operations, and satisfaction with their care. Patients discharged prior to implementation of the form (PRE) were then compared to those that received the form upon discharge (POST).

Results: 153 surveys were distributed and 146 were returned and comprised the database. 46 patients (32%) were discharged prior to introduction of the form and comprised the PRE group and 100 (68%) received the form upon discharge and comprised the POST group. 71% of patients were male, with a median age of 32. 59% reported annual household incomes of < $25,000 and 67% had an education level of high school diploma or less. Both the PRE and POST groups were comparable in terms of age, gender, health insurance status, income and education. There was a significant increase in the percentage of patients in the POST group able to correctly recall any provider (31% vs 11%, p=0.009), their injuries and operations compared to the PRE group (Tables). This translated into increased patient understanding (55% vs 35%, p=0.035) and overall patient satisfaction (74% vs 53%, p=0.016) in the POST group.

Recall	PRE	POST	p
Injury			0.0001
None	48%	15%	
Some	22%	29%	
All	30%	56%	

Recall	PRE	POST	p
Operation			0.0012
None	57%	23%	
Some	14%	20%	
All	29%	57%	

Conclusions: Introduction of a simple discharge information form coupled with directed patient education dramatically improved the injury specific health literacy of our patients. Specifically, they were able to confer to the outpatient healthcare provider post-discharge medically relevant features of their care. This study represents an important first step in the ongoing efforts to improve injury comprehension, health literacy and ultimately health outcomes in the trauma patient population.

DEPRESSION PREDICTS LONG-TERM COGNITIVE IMPAIRMENT IN SURVIVORS OF CRITICAL ILLNESS

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Vanderbilt University Medical Center

Invited Discussant: Matthew Lissauer, MD

Introduction: Our group has shown Intensive Care Unit (ICU) survivorship is associated with long-term cognitive impairment (LTCI). We have found an incidence of depression in up to 30%, and Post-Traumatic Stress Disorder (PTSD) in up to 10% of ICU survivors. The goal of this study is to identify the impact of post-ICU mental health disorders on cognition after critical illness. We hypothesized that depression and PTSD are independently associated with LTCI in ICU survivors.

Methods: This is a five-center (2 civilian, 3 Veteran Affairs) nested prospective cohort of critically ill patients admitted to medical and surgical ICUs in shock and/or respiratory failure, who underwent neuropsychological assessments at 3 and 12 months post hospital discharge. Our primary outcome was global cognition using the Repeatable Battery for the Assessment of Neuropsychological Status (RBANS) at 12 month follow-up. Our independent variables were depression (Beck Depression Inventory-II, BDI-II) and PTSD (PTSD Checklist, PCL-S) measured at 3 and 12 months. We performed multivariable linear regression models controlling for covariates such as age, years of education, pre-existing cognitive impairment, Charlson comorbidity index, duration of mechanical ventilation, episodes of hypoxemia, and days of delirium or coma.

Results: There were 590 patients included with a median age of 61 (IQR: 52-70), enrollment Sequential Organ Failure Assessment (SOFA) score of 6 (IQR: 4 - 8), 520 (88%) mechanically ventilated, and 420 (71%) with delirium. Of ICU survivors, 113 (19%) had PTSD and 187 (32%) had depression at 3 months. At 12 months, median RBANS was 80 (IQR 71-87). Depression at 3-months was associated with lower 12-month RBANS (coefficient=-0.409 95% CI -0.813, -0.005 p=0.048). PCL score at 3-months had no association with global cognition at 12 months (coefficient=-0.244, 95% CI -0.732, 0.244, p=0.326). In sensitivity analysis, accounting for PCL increased the effect of depression on cognition at 12 months (coefficient=-0.646 95% CI -1.159,-0.134 p=0.014) and was found to primarily affect the subdomains of immediate (coeff. -0.742 95% CI -1.394, -0.090 p=0.026) and visuospatial memory (coeff -0.720 95% CI -1.325, -0.115 p=0.020).

Conclusions: Early post-ICU depression, but not PTSD, is independently associated with LTCI. When PTSD is controlled for, the effect of depression on cognition is increased. Treatment for early depression represents a novel intervention area for LTCI prevention in ICU survivors.

Session IX: Plenary Papers 52-59
Paper 59: 2:20 PM - 2:40 PM

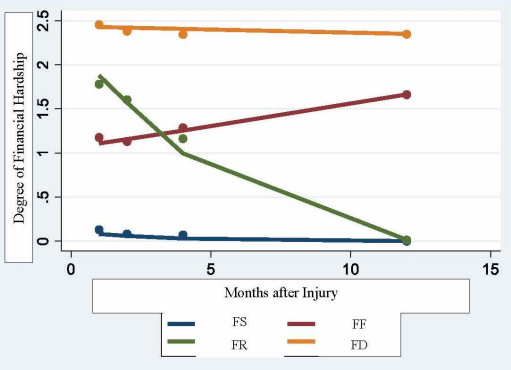
PATIENTS FOLLOW DIFFERENT FINANCIAL HARDSHIP TRAJECTORIES IN THE YEAR AFTER INJURY

Madhuri Nishtala MD, Lava Timsina PhD, Sarah Severance MD, Stephanie A. Savage MD, MSc, Ben L. Zarzaur MD, MPH, University of Wisconsin School of Medicine and Public Health

Invited Discussant: Joseph Minei, MD, MBA

Introduction: After serious illnesses or injury, lost wages, forced unemployment, and other financial burdens contribute to financial worry and poor coping mechanisms that may impair recovery. Collectively, this phenomenon is known as financial hardship or toxicity. While well-studied in cancer, financial hardship is less understood after injury. Previously, we found that experiencing a single episode of financial hardship during recovery after injury is associated with lower quality of life and more psychological distress compared to those without financial hardship. However, recovery is dynamic and patients may move in and out of financial hardship over time. We hypothesized that patients would follow distinct financial hardship trajectories and that these trajectories would be associated with Health Related Quality of Life (HRQoL) outcomes.

Methods: Adults (age $\geq$ 18) with injury severity score (ISS) > 9 but without brain or spinal cord injury were prospectively enrolled and followed for one year. Financial hardship was measured at 1, 2, 4 and 12 months after injury using four questions that covered changes in material conditions and the psychological response. Financial hardship was graded on a scale of 0 – 4 based on the number of positive responses to questions in each domain. The Short-Form 36 (SF-36) was used to asses HRQoL outcomes. Group-based trajectory modeling was employed to identify underlying financial hardship trajectories in the year after injury. Univariate and multivariable analysis identified factors associated with each trajectory and HRQoL outcomes.



Results: 500 patients were enrolled and group-based trajectory modeling revealed that patients followed one of four financial hardship trajectories in the year after injury (FIGURE). Financial Security (FS) was associated with no change in trajectory over time (8.4%). Financially Devastated (FD) patients showed a significant degree of hardship in the first month after injury and never recovered (51.6%). Financially Frail (FF) patients suffered a slow increase in the degree of financial hardship over time (33.6%). Financially Resilient (FR) patients started off with a high degree of hardship but were able to recover by the end of the year (6.2%). Only 15% of patients experience a favorable trajectory (FS and FR). Factors associated with the groups based on post-injury financial hardship trajectory, as well as HRQoL outcomes by trajectory, are shown in the TABLE.

Table. Factors and outcomes associated with various financial hardship trajectories in the year after injury.

	Financially Secure (n=43,8.4%)	Financially Frail (n=168,33.6%)	Financially Resilient (n=31,6.2%)	Financially Devastated (n=258,51.6%)	p-value
Age	45.8±18.2	37.7±14.1	35.6±15.3	36.5±13.5	0.0011
Male (%)	60.5	60.1	51.6	70.1	0.0560
Race/Ethnicity (%)					
Non-White	58.1	55.4	48.4	46.5	0.2320
Socioeconomic Status (Gini Index)	0.41±0.07	0.42±0.28	0.42±0.06	0.43±0.06	0.3624
Insurance Status (%)					
Self-Pay	14.0	41.7	38.7	48.1	0.0010
Injury Severity Score	20.0±10.5	20.6±10.4	18.5±7.7	21.0±9.7	0.5798
Mechanism of Injury (%)					
Blunt	79.1	79.8	83.9	72.5	0.111
Length of Stay	11.9±8.9	12.6±7.7	12.8±11.7	12.7±9.1	0.9557
Readmission (%)	9.3	6.0	6.5	10.5	0.415
SF-36					
Mental Component Score	56.3±11.3	41.8±13.1	54.0±7.9	41.8±13.1	<0.001
Physical Component Score	42.1±14.7	34.8±10.4	46.3±11.1	33.2±10.5	<0.001

Conclusion: Experiencing an unfavorable financial hardship trajectory was associated with not only worse psychological outcomes but also worse physical outcomes. Physical recovery may be impaired by coping strategies associated with financial hardship, such as avoidance of needed rehabilitation. Interventions to improve HRQoL outcomes should consider alleviating financial hardship as a component of the intervention.

ENDOVASCULAR VS OPEN MANAGEMENT OF TRAUMATIC ILIAC ARTERY INJURIES: A REVIEW OF THE AMERICAN ASSOCIATION FOR THE SURGERY OF TRAUMA PROSPECTIVE OBSERVATIONAL VASCULAR INJURY TRIAL (PROOVIT) REGISTRY

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Wright State University

Invited Discussant: Nicole Stassen, MD

Introduction: The American Association for the Surgery of Trauma PROspective Observational Vascular Injury Trial (PROOVIT) database has been collecting prospective data on vascular trauma since 2013. The aim of this review is to provide a contemporary analysis of the management and outcomes of iliac artery injuries using the PROOVIT database.

Methods: Registry data from March 2013 to November 2019 were reviewed. All trauma patients who had an injury to the iliac artery were included. Patients with missing data points were excluded from relevant analyses. The primary outcome was in-hospital mortality. Secondary outcomes were mean 24-hour pRBC transfusion requirements, need for reintervention, amputation rate, ventilator free days, and ICU free days.

Results: Two hundred iliac artery injuries were identified, and sufficient data for full analysis was available for 148. Penetrating mechanisms were responsible for 31.9% (61/191) and blunt mechanisms for 68.1% (130/191) of the injuries for which mechanism was known. An open approach was performed in 68 patients while 78 patients were managed with endovascular techniques. Of the 68 open repairs, 43 (63.2%) were for penetrating injury while 25 (36.8%) were for blunt. Of the 78 endovascular repairs, 11 (14.1%) were for penetrating injury while 67 (85.9%) were for blunt. The mortality rate for those managed endovascularly was 22.4% (17/76) vs. 44.6% (29/65) in those who underwent open approach (p=.005). Iliac artery injuries managed with endovascular rather than open techniques had a statistically lower mean 24-hour pRBC transfusion requirement (6 vs 11 units; p=.002) despite the endovascular group having a higher ISS than the open group (26 vs 19; p=.048). Although not statistically significant, the reintervention rate following open approach was 14.7% (10/68) vs. 6.6% (5/76) for endovascular intervention (p=.111). No difference in amputation rates was noted between groups (4.4% open vs. 3.9% endovascular; p=.111). Patients who survived to discharge did not have statistically significant differences in ICU free days (p= .469) or vent free days (p =.483) when calculated out of 28 days.

Conclusions: Our review of PROOVIT registry data demonstrates that endovascular intervention has become increasingly prominent in the management of both blunt and penetrating iliac artery injuries, and is now more common overall than open approaches. In addition, mortality and blood transfusion rates were noted to be significantly lower in the endovascular than open group despite the endovascular group having a significantly higher ISS. Among survivors, no difference in vent free days or ICU free days was noted between the endovascular or open management groups.

Session X: Plenary Papers 60-65
Paper 61: 2:20 PM - 2:40 PM

BEYOND THE HEADLINES: A DETAILED ANALYSIS OF 19 YEARS OF MASS SHOOTINGS ACROSS THE UNITED STATES

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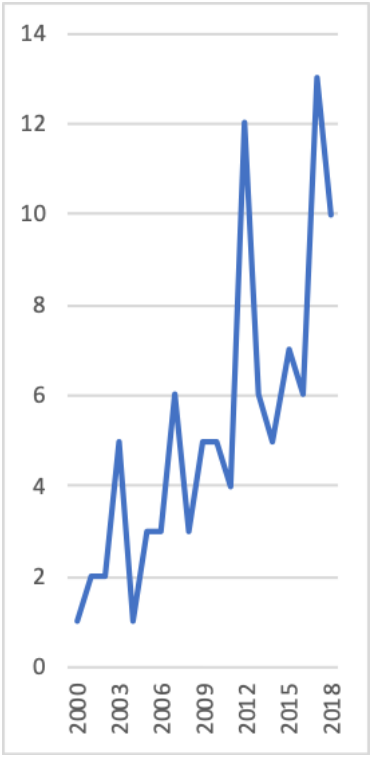
Department of Surgery, University of Tennessee Health Science Center

Invited Discussant: Deborah Kuhls, MD

Introduction: Mass shootings, defined by the US Congress as the murder of three or more people in a public space, have captured the nation's attention over the past several years. Due to increased media focus, the public now perceives this as an increasing threat. Whether this translates to an ominous and increasing trend, or whether early clues to shootings can thwart these killings remains to be established. The goal of this study was to better characterize the phenomenon and identify potentially preventable factors of mass shootings.

Methods: Mass shootings in the United States from 2000-2018 were obtained from the FBI's active shooter registry. Catastrophic mass shootings, defined as the murder of more than nine people in a public space, were also evaluated. Data analyzed included number of deaths, firearm type, caliber, social media postings, psychiatric history, and demographics. Rates of mass shootings per 100M population were stratified by year and compared over time using simple linear regression.



Results: 99 incidents of mass shootings were identified over the study period. Of these, 15 (15%) were catastrophic mass shootings. The median number of deaths per shooting was 5 (range 3-58) and the majority (95%) involved a single shooter. Most shooters were young (mean age of 36), white (55%), and male (95%). 53 had a known psychiatric history and 46 had documented aberrant social media activity prior to their shootings. Handguns (alone or in combination) were the most common type of firearm used (81%). High velocity weapons accounted for 26% of all mass shooting incidents, but 53% of catastrophic mass shootings involved high velocity weapons ($p=0.022$). Aberrant social media postings occurred in 41% of mass shootings with 9 or fewer deaths, and in 80% of catastrophic mass shootings ($p=0.005$). The number of mass shootings per year increased over the study period (Figure). Linear regression analysis identified a significant increase in the incidence of mass shootings per 100M population from 0.36 in 2000 to 3.1 in 2018 ($\beta = 0.15$, $p < 0.0001$).

Conclusions: Consistent with popular perception, mass shootings have increased over the past 19 years. While recent efforts at gun reform have focused on high velocity semi-automatic weapons, the dominant role that handguns play in these murders should not be ignored. Given the recent rise in popularity of 'red-flag' laws, identification of worrisome social media posts should play a future role in preventing these tragic attacks.

THE PREHOSPITAL USE OF YOUNGER AGE WHOLE BLOOD IS ASSOCIATED WITH AN IMPROVED ARRIVAL COAGULATION PROFILE

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University of Calgary - Cumming School of Medicine

Invited Discussant: Jason Sperry, MD

Introduction: Recent *in vitro* data has shown that the hemostatic profile of WB degrades significantly after 14-days, yet the optimal storage remains debated. We hypothesized that arrival coagulation studies would be improved in patients receiving younger WB in the prehospital setting.

Methods: This study was approved by our institutional IRB. We evaluated all trauma patients who received prehospital blood products by our helicopter service between 07/17-07/19. "Young" WB was defined as 14-days or less. Patients who received at least one unit of "young" WB in the prehospital setting were classified as YOUNG, while the remainder were classified as OLD. Continuous data are presented as medians (25th-75th IQR) with comparisons performed using Wilcoxon Rank sum. Assessments of clinical hemostatic potential included arrival platelet cell count and rapid thrombelastography (r-TEG). Univariate analysis, including one-way ANOVA with repeated measures, was performed (STATA 12.1).

Results: 220 patients received prehospital WB during the study period. Of these, 153 patients received YOUNG WB, while 67 were transfused only OLD WB units. There were no differences in demographics, prehospital or arrival physiology, or injury severity score among the two groups. The measures of clot initiation (ACT) and kinetics (K-time) were improved, as were the measures of clot acceleration/fibrinogen function (angle), and platelet function (MA). As well, arrival platelet count was higher in the YOUNG cohort (TABLE). Though a trend towards less post-arrival transfusion were noted, this was not statistically significant (p=0.220).

Conclusion: Previous *in vitro* data has suggested deterioration of platelet function in cold-stored WB after 14-days. The current study demonstrated decreased global hemostasis by clinically available labs, especially related to fibrinogen and platelet interactions. In this small single center study, this did not translate into increased transfusion requirements. Further studies are needed to determine the optimal storage duration for cold-stored WB for transfusion in the bleeding trauma patient.

TABLE: Hemostatic profile between YOUNG vs OLD whole blood

	YOUNG (n=153)	OLD (n=67)	p-value
r-TEG ACT	113 (105, 121)	113 (105, 128)	0.080
r-TEG K-time	1.5 (1.1, 1.8)	1.8 (1.2, 2.1)	0.024
r-TEG angle	73 (70, 76)	71 (66, 75)	0.014
r-TEG MA	63 (58, 68)	60 (55, 65)	0.063
r-TEG LY-30	0.6 (0.0, 2.7)	0.6 (0.0, 1.8)	0.612
Platelet count x1000	198 (137, 255)	170 (131, 229)	0.050

Session X: Plenary Papers 60-65
Paper 63: 3:00 PM - 3:20 PM

VALIDATION OF A NOMOGRAM PREDICTING BLEEDING CONTROL INTERVENTIONS AFTER HIGH-GRADE RENAL TRAUMA

Sorena Keihani MD, MSc, Joel Gross MD, Ryan Joyce MD, Sherry Wang MD, Douglas Rogers MD, Judith Hagedorn MD, J. Patrick Selph MD, Rachel Sensenig MD, Rachel Moses MD, MPH, Shubham Gupta MD, Nima Baradaran MD, Joshua Broghammer MD, Angela Presson PhD, Raminder Nirula MD, MPH, Jeremy Myers MD
Department of Surgery, University of Utah

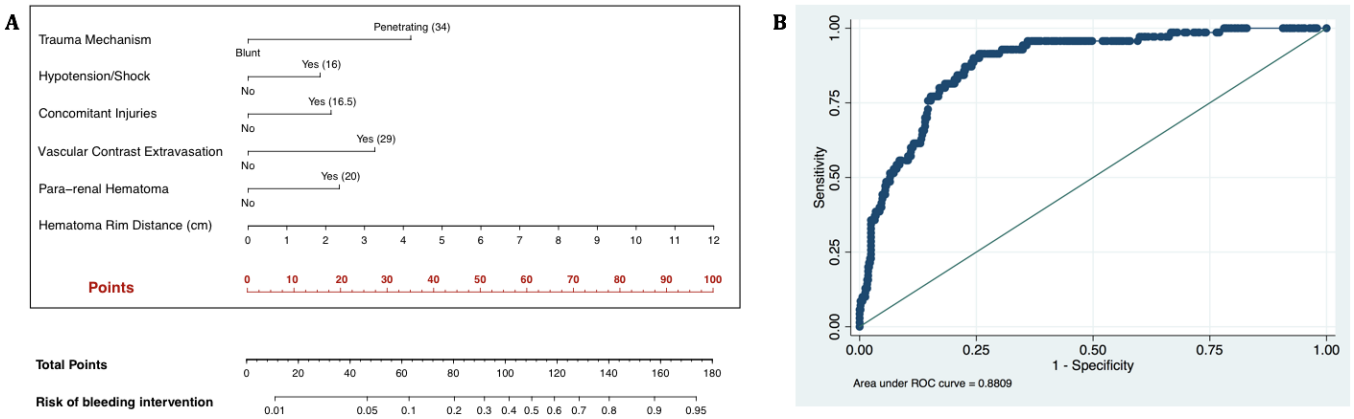
Invited Discussant: Andre Campbell, MD

Introduction: Renal trauma grading has a limited ability to distinguish patients who will need interventions after renal trauma. A nomogram incorporating both clinical and radiologic factors has been previously developed to predict bleeding control interventions after high-grade renal trauma (HGRT). We aimed to externally validate this nomogram using multi-center data from level-1 trauma centers.

Methods: We gathered HGRT (AAST grades III-V) data from 7 Level-1 trauma centers. Two radiologists, blinded to the intervention data, reviewed the initial CT scans, when available. Nomogram variables included: 1. trauma mechanism (penetrating vs. blunt); 2. hypotension/shock; 3. concomitant injury (i.e. any solid organ, gastrointestinal, spinal cord, or major vascular injury, or pelvic fracture); 4. vascular contrast extravasation (VCE); 5. pararenal hematoma extension (beyond aorta on left or IVC on right or into the pelvis); and 6. hematoma rim distance (HRD, i.e. largest measure from the edge of the kidney to the hematoma). Bleeding interventions included nephrectomy, partial nephrectomy, renorrhaphy, renal packing, and renal angioembolization. Mixed-effect logistic regression, with clustering by facility, was used to assess the associations. The prediction accuracy of the nomogram was assessed using the area under the receiver operating characteristic curve (AUC) and its 95% confidence interval (CI).

Results: A total of 560 HGRT patients with a median (interquartile range) age of 32 (23-47) years were included. Median injury severity score was 27 (17-38). Trauma mechanism was blunt in 89%. Injuries were grade III, IV, and V in 58%, 35%, and 7%. Overall, 71% had concomitant injuries and 21% presented in shock. Using initial CT scans, 14% had VCE and 37% had pararenal extension of hematoma. Median HRD was 1.7 (0.9-2.6) cm and 14% had an HRD≥3.5 cm. Overall, 88% underwent expectant management and 12% underwent bleeding control interventions including 34 angioembolizations and 26 nephrectomies. Presence of VCE was associated with 7.5-fold increase in odds of bleeding interventions (95% CI: 4.3–13.2). Every cm increase in HRD was associated with 88% increase in odds of bleeding interventions (OR:1.88; 95% CI: 1.61–2.19) and an HRD≥3.5 cm was associated with 7.7-fold increase in odds of intervention (95% CI: 4.4–13.6). In the multivariable analysis validating the nomogram variables, the model provided excellent discrimination (AUC: 0.88; 95% CI: 0.84–0.92).

Conclusions: Our results reinforce the importance of select radiologic findings in predicting interventions after renal trauma. The prediction accuracy of the proposed nomogram remains high using external data. These variables can help to better risk stratify renal injuries and to potentially reduce the number of unnecessary renal explorations.



A) The MiGUTS (Multi-institutional Genito-Urinary Trauma Study) nomogram for predicting bleeding interventions after high-grade renal trauma.
B) Receiver operating characteristic curve for validation of the nomogram using external data (AUC=0.88, 95% CI:0.84–0.92)

PROLONGED METABOLOMIC ALTERATIONS CHARACTERIZE PERSISTENT INFLAMMATION, IMMUNOSUPPRESSION, AND CATABOLISM SYNDROME AFTER SEVERE TRAUMA

Dara L. Horn MD, Lisa Bettcher BS, Joseph Cuschieri MD, Raftery Daniel PhD, Grant E. O'Keefe MD, MPH
University of Washington

Invited Discussant: Paul Bankey, MD

Introduction: Following trauma, persistent inflammation, immunosuppression, and catabolism are proposed to characterize delayed recovery or failure to recover. Understanding the metabolic pathways associated with these adverse outcomes may facilitate rapid identification and intervention. We sought to characterize the metabolomic profiles of trauma victims who die or develop chronic critical illness (CCI), and hypothesize that evidence of inflammation, immunosuppression, and catabolism would exist by 7 days after injury.

Methods: Trauma victims ≥ 16 years old with shock (SBP < 90 mmHg or base deficit ≥ 6 meq/L) were eligible. We excluded those with isolated severe neurologic injury. Venous blood samples collected at multiple time points were analyzed using mass spectrometry. Subjects who died or developed CCI (ICU LOS ≥ 14 days with persistent organ dysfunction) were compared to subjects who recovered rapidly (ICU LOS ≤ 7 days with no organ dysfunction), as well as uninjured controls. Principal component analysis (PCA), pathway enrichment and topology analyses, and *t*-tests were used to make broad metabolomic comparisons and identify differences in metabolic pathways and metabolite concentrations. Statistical significance was defined as a $p < 0.01$ after correcting for multiple comparisons.

Results: Of 120 eligible subjects, 5 died, 22 developed CCI, and 33 recovered rapidly. The median age was 53 years [IQR 26-61]. Subjects were predominantly male (65%) with a median ISS of 36 [IQR 29-45]. Healthy controls (n = 48) had similar age and sex distributions. Differences between injured subjects and controls, and between injury outcome groups were observed on PCA as early as 12 hours and 1 day post-injury, respectively. Comparing injury outcome groups, 36 metabolites differed significantly on day 7 and represented alterations in pathways involved in inflammation ($p < 0.001$), oxidative stress ($p < 0.001$), and amino acid metabolism ($p < 0.001$). Figure 1 plots the relative concentrations of three central metabolites in each pathway—arachidonate, kynurenine, and serine—on day 7 compared to controls.

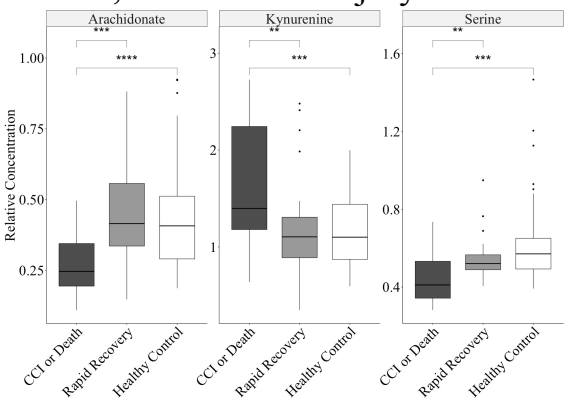


Figure 1: Relative metabolite concentrations on day 7 by group, compared to healthy controls (** p < 0.01, *** p < 0.001, **** p < 0.0001).

Conclusions: Seven days post-injury, metabolomic profiles in subjects who ultimately die or develop CCI differ significantly from those who have recovered with alterations in inflammation, immunosuppression and catabolism. This is the first study to use metabolomics to define potentially modifiable characteristics of adverse outcomes following trauma.

TRAUMA BAY VIRTUAL REALITY - A GAME-CHANGER FOR ATLS INSTRUCTION AND ASSESSMENT

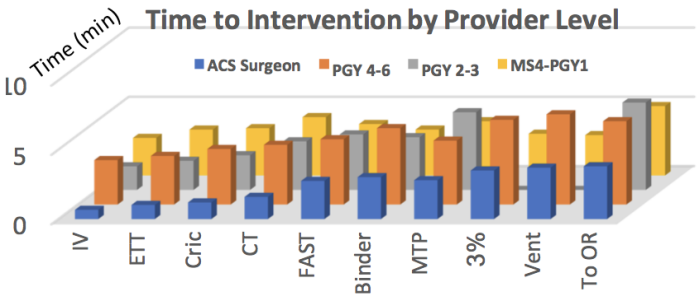
Alexander L. Colonna MD, MSCI, Riann Robbins MD, Jeanine Stefanucci PhD, Mark Durham, Sarah Creem-Regehr PhD, Brandon Patterson MSc, Benjamin Engel MSc,
Raminder Nirula MD, MPH
University of Utah

Invited Discussant: Daniel Grabo, MD

Introduction: Medical education research highlights the need for high-fidelity, multidisciplinary, simulation training to teach complex decision-making skills such as those taught in ATLS. This approach, however, is expensive and time-intensive, limiting ATLS availabilty. Virtual reality (VR) education simulation may improve skill acquisition in a cost-effective and time-sensistive manner. We developed a novel trauma VR simulator (TVRSim) for providers to apply ATLS principles during a VR trauma resuscitation. We hypothesized the TVRSim could differentiate competency between participants with increasing levels of training and would be well accepted.

Methods: Providers at a level 1 trauma center (trauma attending (reference), novice (MS4 & PGY 1), junior (PGY 2 & 3), senior (PGY 4-6) general surgery residents) ran a blunt, polytrauma VR code. Ten critical decisions points were assessed: intubation, cricothyroidotomy, chest tube, IV access, FAST, pelvic binder, activation of MTP, administration of hypertonic saline (HTS), hyperventilation and decision to go to the OR. Learner assessment was based upon frequency and time to correct decisions. Participant satisfaction was measured using validated surveys.

Results: All 16 providers intubated, obtained IV access, and performed a FAST exam. Seniors, juniors and novices frequently failed at pelvic binder, HTS and hyperventilation decisions. Juniors also often failed at cricothyroidotomy (50%), MTP (50%) and OR (50%) decisions. Novices also failed at chest tube (40%), pelvic binder (40%), MTP (80%), HTS (80%), hyperventilation (80%) and OR (60%) decisions. Mean time to all decisions was longer for all groups compared to the attending.(fig) Mean number of decisions/min was significantly higher for the attending (2.6) compared to others (senior=1.4, junior=1.1, novice=1.4, $p < 0.05$). None of the juniors and novices saved the VR patient while 75% of seniors and the attending succeeded. Participants found TVRSim comfortable, easy to use/interact with/performance enhancing, and helped develop skills and learning.



Conclusions: TVRSim was able to discern decision-making abilities among trainees with increasing training level through measuring a combination of number of correct decisions, time to decision and survival of the VR patient. All trainees felt the platform enhanced their performance and facilitated skill acquisition and learning. If TVRSim is further validated, it could be a useful adjunct to teach and test trauma resuscitation skills on an individual level or as part of ATLS.