OPTIMIZATION BRAIN METABOLISM USING METABOLIC-TARGETED HYPOTHERMIA THERAPY CAN REDUCE MORTALITY OF TRAUMATIC BRAIN INJURY

Wen-yuan Wang MBBS, Jin-zhou Feng MBBS, Jun Zeng MBBS, Zhi-yuan Zhou BS, Jin Peng Ph.D., Hao Yang Ph.D., Shi-jun Li MBBS, Charles D. Lu Ph.D.,
Sichuan Academy Of Medical Sciences

Invited Discussant: Daniel Eiferman, MD

Introduction: Hypothermia therapy has been widely used to treat traumatic brain injuries (TBI). But a major challenge remains: how to target hypothermia therapy. We hypothesized that lowering metabolic rate should be the target of hypothermia therapy rather reaching a fixed body temperature. We assumed that optimizing metabolic conditions, especially the brain metabolic environment, could offer better benefit to neurologic protection. We designed a RCT to test this hypothesis and conducted a metabolomics study to explore the mechanic.

Methods: This is a single-blind randomized controlled trial. Severe TBI patients with Glasgow Coma Scale (GCS) ranged 3-8 were randomly divided into 1) the study group: 50-60% rest metabolic ratio as the target of hypothermia therapy (metabolic targeted hypothermia treatment: MTHT); 2) the control group: 32-35°C body temperature was set as the target of hypothermia therapy (body temperature targeted hypothermia treatment: BTHT). The intervention time was 7 days for both groups. The brain metabolic pool (through jugular vein) and circulatory metabolic pool (through subclavian vein) serum samples were collected at the baseline, and on days 1, 3 and 7 during the hypothermia treatment. In total, 112 serum samples were collected from 8 participants from the MTHT group and 6 from the BTHT group. The primary outcome was mortality. Using the 1H-NMR technology, we tracked and located the disturbances of metabolic networks.

Results: Eighty-three severe TBI patients were recruited from December 2013 to December 2014, of which 42 were assigned to the MTHT group and 41 were assigned to the BTHT group. The mean age was 39.65±10.06 years, 68.67% participants were male, and GCS 6.25±0.97. The mortality of the MTHT group was significantly lower than that of the BTHT group (5 vs. 12, p=0.050). When serum samples were analyzed, there was significant difference between the brain and circulatory metabolic patterns in the MTHT patients compared with the BTHT patients (see figure). And we found a group of metabolites through 1H-NMR metabolomics, which can be used as neuro-protective monitoring parameters for hypothermia treatment.

Conclusion: The MTHT appears to be an ideal strategy that can significantly reduce the mortality of severe TBI patients. Metabolomics research showed that this strategy could effectively improve brain metabolism, suggesting that reducing metabolic rate by 40%~50% should be set as the target of hypothermia therapy. In addition, 1H-NMR based metabolomics is a time sensitive and easy-to-use high-throughput tool that can be applied in clinical evaluation for TBI treatment.

The PLS-DA Scores Plot of MTHT
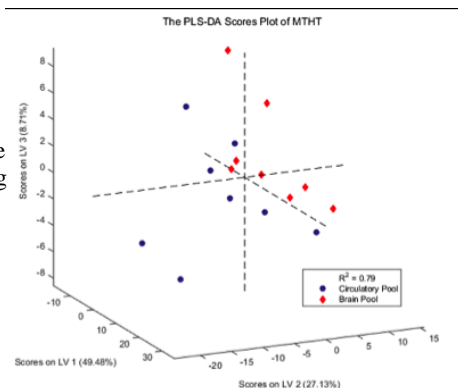
STAPLED VS HANDSEWN : A PROSPECTIVE EMERGENCY SURGERY STUDY (SHAPES)

Brandon R. Bruns MD, David S. Morris MD, Toby M. Ennis MD, Alisan Fathalizadeh MD,MPH, Joseph Sakran MD,MPH, Kristen Arnold MD, Nathan M. Mowery* MD, David Turay, MD, Jason Murry MD, Oliver L. Gunter* MD,MPH, Joseph D. Love DO, Matthew Carrick MD, David Skarupa MD, Anthony Herrera Jose J. Diaz* MD, University of Maryland Medical Center

Invited Discussant: Gregory Jurkovich, MD

Introduction: Data from the trauma patient population suggest handsewn anastomoses (HS) are superior to stapled (ST). A recent retrospective study in emergency general surgery (EGS) patients had similar findings. The aim of the current study is to prospectively evaluate anastomotic failure rates for HS and ST anastomoses in EGS patients undergoing urgent/emergent operations.
Methods: The study was sponsored by the AAST Multi-Institutional Studies Committee. Patients undergoing urgent/emergent bowel resection for EGS pathology were prospectively enrolled from 7/22/2013-12/31/2015. Patients were grouped by HS vs ST anastomoses and demographic and clinical variables were collected. The primary outcome was anastomotic failure. Similar to other studies, anastomotic failure (leak, abscess, fistula) was evaluated at the anastomosis level. Multivariable logisitic regression was performed controlling for age and risk factors for anastomotic failure.
Results: Fifteen institutions enrolled a total of 595 patients with 649 anastomoses (253 HS and 396 ST). Mean age was 61-years and 51% were male with 7% overall mortality. Age and sex were the same between groups. The overall anstomotic failure rate was 12.5%. The HS group had higher lactate (2.1 vs 1.6, p<0.01) and lower albumin (3.2 vs 3.5, p<0.01). Hospital and ICU days, as well as mortality, were all greater in the HS group. Anastomotic failure rates and operative time was similar for HS & ST techniques (TABLE). On multivariate regression, the presence of contamination at initial bowel resection (OR 1.965; 95% CI 1.183-3.264) and the patient being managed with an open abdomen (OR 2.529; 95% CI 1.492-4.286) were independently associated with anastomotic failure, while the type of anastomosis (HS vs ST) was not.
Conclusion: EGS patients requiring bowel resection and anastomosis are at high risk for anastomotic failure. The current study illustrates an apparent bias among acute care surgeons to perform HS anastomoses in higher risk patients. Despite the individualized application of anastomotic technique for differing patient populations, the risk of anastomotic failure was equivalent when comparing HS and ST techniques.

	HS	ST	p-value
Anastomotic Failures, n (%)	39 (15.4)	42 (10.6)	0.07
Failures by Type, n (%)			
Small bowel to small bowel	31/204 (15)	25/262 (10)	0.06
Small bowel to large bowel	4/35 (11)	11/104 (11)	0.89
Large bowel to large bowel	4/14 (29)	6/30 (20)	0.53
Operative Time, min*	165 [120-218]	152 [104-222]	0.13
Hospital LOS*	14 [9-24]	10 [7-18]	<0.01
ICU LOS*	5 [0-13]	0 [0-5]	<0.01
Mortality, n (%)	36 (14.2)	20 (5.1)	<0.01

WeBET THAT WEIGHT BASED ENOXAPARIN DOSING DECREASES DVT IN HOSPITALIZED TRAUMA PATIENTS: A RANDOMIZED, CONTROL, DOUBLE BLIND TRIAL

Annika B. Kay PA-C, Sarah Majercik* MBA, MD, Thomas W. White MD, Jeffrey Sorensen MStat, Scott M. Stevens MD, Scott C. Woller MD, Joseph Bledsoe MD, Intermountain Medical Center

Invited Discussant: Gerald Fortuna, Jr., MD

Introduction: Venous thromboembolism (VTE) is a major cause of morbidity and mortality in trauma patients. Currently, chemoprophylaxis with low molecular weight heparin (LMWH) at a standardized dose is recommended, regardless of body mass index (BMI). There is some evidence that conventional chemoprophylaxis may be inadequate in high-risk patients. We hypothesized that a weight-adjusted enoxaparin prophylaxis regimen would reduce the frequency of VTE in hospitalized trauma patients and at 90 day follow up.

Methods: This is a prospective, randomized, double-blind control trial of adult patients weighing $\geq$ 60kg admitted to the trauma service at a single Level One Trauma Center between July 2013 and January 2015. Exclusion criteria included any contraindication to immediate chemoprophylaxis, history of coagulation abnormality, or pre-injury use of anticoagulants/antiplatelet agents. Subjects were randomized to receive either standard (ST) (30 mg SQ every 12 hours) or weight-based (WB) (0.5mg/kg SQ every 12 hours) enoxaparin dosing. Surveillance duplex ultrasound (DUS) for asymptomatic lower extremity deep vein thrombosis (DVT) was performed on hospital days 1, 3, 7, and weekly thereafter. Symptomatic VTE was pursued at the discretion of the attending surgeon. The primary outcome was DVT during the index hospitalization. Secondary outcomes included VTE at 90 days, significant bleeding events, thrombocytopenia or other suspected adverse drug reactions.

Results: 238 (127 ST, 111 WB) subjects were enrolled in the study. There was no difference between ST and WB groups with regard to age, admission BMI, gender, ISS, or percentage that had a surgical procedure. The WB group tended to be more likely to have a lower extremity AIS $\geq$ 2 (p=0.07). Mean enoxaparin dose in the WB group was higher than the STD group, as expected (43mg vs. 31mg, p<0.001). Lower extremity DVT tended to occur more frequently during hospitalization in the ST group (12 (9.4%) STD vs. 4 (3.6%) WB, p=0.11). At 90 day follow up, there was no difference in VTE rate (12 (9.4%) ST vs. 7 (6.3%) WB, p=0.51). ST group developed DVT sooner than the WB group (2.5±2 days ST vs. 10.1±7.6 days WB, p<0.001). Subgroup analysis of subjects with ISS>15 (27 ST, 24 WB) found no difference in in-hospital DVT between ST and WB (11.1% ST vs. 4.2% WB, p=0.6). There was one major bleeding event, which occurred in a ST subject. There was one pulmonary embolism, which occurred in a ST subject.

Conclusion: WB enoxaparin dosing for VTE chemoprophylaxis in trauma patients appears to be safe and may result in a lower rate of VTE during the index hospital stay. WB dosing does lead to more DVT-free hospital days. This protective effect does not appear to extend out to 90 days after hospital discharge, however. Larger scale studies are necessary to determine whether WB dosing is superior to ST.

ACUTE RIGHT HEART FAILURE AFTER TRAUMA PNEUMONECTOMY – IS IT PREVENTABLE?: A BLINDED RANDOMIZED CONTROLLED ANIMAL TRIAL USING INHALED NITRIC OXIDE (iNO)

Andrea L. Lubitz MD, Lars O. Sjoholm MD, Amy Goldberg* MD, Zoe Maher MD, Abhijit Pathak* MD, Thomas Santora* MD, Thomas E. Sharp III, Ph.D. Candidate, Markus Wallner MD, Remus M. Berretta BS, Lauren A. Poole BS, Jichuan Wu MD,Ph.D., Marla R. Wolfson Ph.D., Katz School Of Medicine At Temple University

Invited Discussant: James O'Connor, MD

Introduction: Trauma pneumonectomy is associated with mortality rates ranging from 50-100%, mainly thought to be related to right heart failure. An acute increase in pulmonary vascular resistance (PVR) occurs from the combination of pneumonectomy and hemorrhagic shock. Ultimately, the increase in PVR and associated increase in right ventricular (RV) afterload leads to acute RV failure, thus reducing left ventricular (LV) preload and output. Inhaled nitric oxide (iNO) lowers PVR by relaxing pulmonary arterial smooth muscle without remarkable systemic vascular effects. We hypothesized that with hemorrhagic shock and pneumonectomy, iNO can be used to decrease PVR and mitigate right heart failure. **Methods**: A simulated hemorrhagic shock and pneumonectomy model was developed using anesthetized sheep (n=12). Sheep received lung protective ventilatory support and were instrumented to serially obtain measurements of hemodynamics, gas exchange and blood chemistry. Heart function was assessed with echocardiography. A median sternotomy was performed and then sheep were randomized to study gas of iNO 20 ppm (n = 6) or nitrogen as placebo (n = 6). Baseline (BL) measurements were obtained, after which hemorrhagic shock was initiated by exsanguination to a target of 50% of the baseline mean arterial pressure (MAP). Within 15 mins of reaching the target MAP, the resuscitation phase (RP) was initiated, consisting of simultaneous left pulmonary hilum ligation, re-infusion of blood and initiation of study gas. Animals were then monitored for 4 hrs. Data were analyzed by multifactor ANOVA for time and treatment group. **Results**: At the initiation of the RP, all animals had an initial increase in PVR. PVR continued to increase with placebo, whereas with iNO, PVR decreased back to BL over time. While both groups experienced an initial increase in RV pressure overload from BL [ie. Eccentricity Index (EI) in systole], this increase was less in animals treated with iNO. Over time, the EI continued to increase with placebo, whereas with iNO it returned to BL values within 2 – 3 hrs. While both groups demonstrated a decrease in RV contractility [RV dP/dT], with iNO the RV dP/dT returned to BL values by 2 hrs, but remained decreased with placebo. RV and LV wall motion [Fractional Area of Change (FAC)], and LV ejection fraction continued to decrease following RP with placebo but remained within BL value with iNO. Lactate [mmol/L] increased and SvO2 [%] decreased from BL initially with RP in both groups. Over time and by 4hrs, with placebo, lactate increased, and SvO2, while increasing from initial RP, remained lower than BL. With iNO, SvO2 returned towards BL, and lactate stabilized. * p < 0.05 vs BL; § p < 0.05 vs Initial RP; # p < 0.05 vs group.

	Baseline		Initial RP		4 hr	
	Placebo	iNO	Placebo	iNO	Placebo	iNO
Lactate	1.20(0.24)	1.12(0.23)	3.40(1.17)*	3.08(0.80)*	5.5(1.2)*	3.7(1.2)*,§
SvO₂	63(6)	62(7)	26.4(5)*	29(3.6)*	44.3(6.1)*,§	62(3.3)#,§

Conclusion: These data indicate that by decreasing PVR, iNO decreased RV afterload, preserved RV and LV function, and tissue oxygenation in this simulated hemorrhagic shock and trauma pneumonectomy model in sheep. This suggests that iNO may be a useful clinical adjunct for trauma patients to mitigate right heart failure and improve survival when pneumonectomy is required.
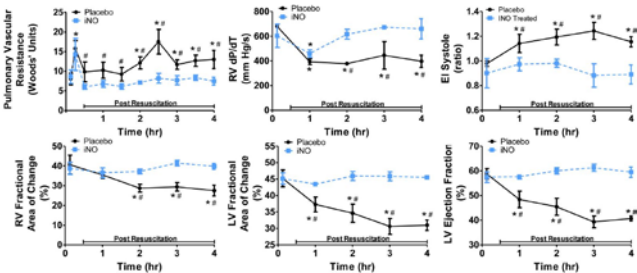
EFFICACY OF LOW MOLECULAR WEIGHT HEPARIN VS UNFRACTIONATED HEPARIN TO PREVENT PULMONARY EMBOLISM FOLLOWING MAJOR TRAUMA: RESULTS FROM THE AMERICAN COLLEGE OF SURGEONS TRAUMA QUALITY IMPROVEMENT PROGRAM

James P. Byrne MD, Stephanie Mason MD, David Gomez MD,Ph.D., Christopher Hoeft MA, Melanie Neal Avery B. Nathens* MD,Ph.D., Sunnybrook Health Science Centre

Invited Discussant: Steven Shackford, MD

Introduction: Pulmonary embolism (PE) is a leading cause of mortality following major trauma. While low molecular weight heparin (LMWH) is often favored over unfractionated heparin (UH) as prophylaxis against venous thromboembolism (VTE), there is limited level 1 evidence demonstrating superiority over UH to justify its higher cost. This study determined efficacy of LMWH compared to UH to prevent PE in patients admitted to trauma centers participating in the ACS Trauma Quality Improvement Program (ACSTQIP).

Methods: Data for adults with severe injury who received VTE prophylaxis with LMWH or UH were derived from ACSTQIP (2012-2014). Two analytic approaches were used. First, the incidence of PE was compared between propensity score (PS)-matched LMWH and UH groups, balanced for patient baseline and injury characteristics, early surgical interventions, and timing of initiation of pharmacologic prophylaxis. Subgroup analyses included: patients with shock, blunt multisystem injury, penetrating truncal injuries, isolated orthopedic trauma and severe traumatic brain injury. Odds ratios (ORs) for PE and 95% confidence intervals (CIs) were estimated using multilevel mixed models, accounting for matched pairs and clustering of patients within centers. Second, a center-level analysis was performed to determine the risk of PE at centers with increasing utilization of LMWH, while accounting for patient case mix. This analysis answered the question of whether trauma centers with a predilection for using LMWH have lower rates of VTE than centers with a greater preference for UH.

Results: We identified 112,031 patients at 214 trauma centers who received LMWH or UH. LMWH was the most common agent used (74%). Patients with older age, greater comorbidity, fall-related and severe head injuries, intracranial hemorrhage, low GCS scores, and early intracranial interventions were more likely to receive UH. PS-matching yielded a well-balanced cohort of 55,212 patients. LMWH was associated with a significantly lower rate of PE compared to UH (1.8% vs. 2.4%; OR 0.70; 95%CI 0.62 – 0.79). This finding was consistent across injury subgroups (Table 1). Our center-level analysis demonstrated that centers with greater utilization of LMWH had lower rates of PE than centers with a greater preference for UH. Specifically, centers in the highest quartile of LMWH utilization (where average 95% of patients received LMWH) had lower rates of PE compared to centers in the lowest quartile of LMWH utilization (where average 42% of patients received LMWH): 1.2% vs. 1.8%; p = 0.02.

Conclusion: Based on these data, VTE prophylaxis with LMWH is associated with lower rates of PE, with a potential to reduce PE rates by more than 25%, compared to prophylaxis with UH. Trauma centers with the greatest utilization of LMWH have lower rates of PE, even after accounting for patient case mix. LMWH should be the preferred agent for VTE prophylaxis after major trauma.

Table 1. Odds of Pulmonary Embolism for Propensity Matched Cohorts

Matched Cohort	Crude PE Rate (%)		OR (95% CI)
	LMWH	UH	
All Patients (n = 55,212)	1.8	2.4	0.70 (0.62 – 0.79)
Shock (n = 3,472)	3.1	4.2	0.67 (0.49 – 0.92)
Blunt Multisystem Injury (n = 16,886)	2.7	3.3	0.75 (0.63 – 0.90)
Penetrating Truncal Injury (n = 3,966)	1.7	2.6	0.49 (0.33 – 0.72)
Isolated Orthopedic Trauma (n = 7,138)	1.0	2.6	0.35 (0.25 – 0.49)
Severe Traumatic Brain Injury (n = 2,732)	0.9	2.1	0.42 (0.21 – 0.84)

SURVEY OF THE AMERICAN COLLEGE OF SURGEONS COMMITTEE ON TRAUMA MEMBERSHIP ON FIREARM INJURY: CONSENSUS AND OPPORTUNITIES

Deborah A. Kuhls* MD, Brendan T. Campbell MD,MPH, Peter A. Burke* MD, Lisa Allee MSW, Barbara A. Gaines* MD, Robert W. Letton* Jr., MD, Mark P. McAndrew MD, Michael L. Nance* MD, Ashley Hink MD, Douglas J. Schuerer* MD, Trudy J. Lerer MS, Ronald M. Stewart* MD, American College Of Surgeons Committee On Trauma

Invited Discussant: Ernest Moore, MD

Introduction: In the U.S. there is a perceived divide regarding the benefits and risks of firearm ownership. The purpose of this survey was to evaluate Committee on Trauma (COT) member attitudes about firearm ownership, freedom, responsibility, physician-patient freedom and policy, with the objective of using survey results to inform firearm injury prevention policy development.

Methods: A 32 question survey was sent to 254 current U.S. COT members by email using Qualtrics. SPSS was used for χ^2, exact, and nonparametric tests, as appropriate with statistical significance being <0.05.

Results: Our response rate was 94%; 43% of COT members have firearm(s) in their home; 87% believe that the ACS should give the highest or a high priority to reducing firearm-related injuries; 86.5% believe healthcare professionals should be allowed to counsel patients on firearm safety. The table summarizes COT surgeon opinions on possible initiatives to prevent firearm violence.

% COT members who strongly agree/agree with advocacy in the following areas	All COT Members	No firearm in home	Firearm in home
Improve mental health treatment to reduce suicides & gun violence	93%	95%	91%
Identify & implement evidenced based injury prevention programs *	93%	97%	87%
Mandatory prosecution of felons who illegally attempt firearm purchase	92%	93%	91%
Increase penalties for illegal gun purchases including gun dealers*	92%	98%	85%
Prevent people with mental health illness from purchasing firearms*	92%	96%	87%
Make funds available for research to understand prevent gun violence*	92%	99%	82%
Preserve health care providers right to counsel patients on gun safety*	90%	95%	84%
Background checks & license/permit for all purchases incl. gun show*	86%	96%	72%
*p <0.05 No firearm in home versus firearm in home			

Conclusion: COT surgeons agree on: 1) the importance of formally addressing firearm injury prevention, 2) the majority of policy initiatives targeted to reduce interpersonal violence and firearm injury and 3) allowing healthcare professionals to counsel patients about firearm injury prevention. It should be possible to leverage these consensus-based results to improve firearm injury prevention and responsible firearm ownership by focusing advocacy efforts where trauma surgeons agree.

AN AAST-MITC ANALYSIS OF PANCREATIC TRAUMA: STAPLE OR SEW? RESECT OR DRAIN?

Nickolas Byrge MD, Marta Heilbrun MD, Lindsay M. Cattin MD, Deborah M. Stein* MD, Todd Neideen MD, Carrie A. Sims* MD, Joseph M. Galante* MD, Ajai Malhotra* MD, Gregory J. Jurkovich* MD, Raul Coimbra* MD, Ph.D., Scott F. Gaspard MD, Mackenzie R. Cook MD, Demetrios Demetriades* MD, Ph.D., George C. Velmahos* MD, Ph.D., Ram Nirula* MD, MPH, University of Utah

Invited Discussant: Timothy Fabian, MD

Introduction: Pancreatic trauma results in high morbidity and mortality due to delay in diagnosis, inadequate sensitivity of CT, and organ function. Morbidity due to pancreatic fistula and pseudocyst significantly impact resource utilization. Operative management varies with respect to how the end of the transected pancreas is closed as well as whether drainage rather than resection should be employed for higher grade injuries, but it is unclear which strategy offers the least morbidity and mortality. We therefore sought to determine CT accuracy in diagnosing pancreatic injury and the morbidity and mortality associated with varying operative strategies.

Methods: We created a multi-center robust, retrospective pancreatic trauma registry from 18 level 1 and 2 trauma centers. Adult, blunt or penetrating injured patients surviving>48 hrs from 2005-2012 were analyzed with CTs independently graded by 3 radiologists at the primary site. Sensitivity and specificity of CT scan identification of main pancreatic duct injury was calculated against operative findings. Independent predictors for mortality, ARDS and pancreatic fistula and/or pseudocyst were identified through multivariate regression analysis. Specifically, the association between outcomes and the manner in which the pancreatic injury was managed was measured.

Results: We identified 704 pancreatic injury patients of whom 584 (83%) underwent a pancreas-related procedure. There was modest correlation between CT grade and OR grade (r2 0.38). Preoperative CT was obtained in 54 of 173 patients with surgically diagnosed ductal injury. CT missed 10 ductal injuries (9 grade 3, 1 grade 4) providing 81.5% sensitivity and 60.3% specificity. Independent predictors of mortality were age, ISS, lactate and # of pRBCs transfused. Independent predictors of ARDS were ISS, GCS and pancreatic fistula (OR 5.2, 2.6-10.1). Among grade 3 injuries (n=130, 18.8%) the risk of pancreatic fistula/pseudocyst was reduced when the end of the pancreas was stapled (OR 0.21, 95% CI:0.05, 0.9) compared to sewn and was not affected by the placement of a duct stitch. Despite pancreatic fistula formation in 118 patients (16.9%) ERCP stent placement was only employed in 8 patients (1.1%). There were insufficient numbers of grade 4 (n=25) and 5 (n=24) injuries to identify independent predictors of outcomes; however, mortality was 4.2% and 12% respectively (p=NS). Drainage alone in grade 4 and 5 injuries carried increased risk of pancreatic fistula/pseudocyst (OR 8.3, 95% CI, 2.2, 32.9).

Conclusion: CT is insufficiently sensitive to reliably identify pancreatic duct injury. Patients with grade 3 injuries should have their resection site stapled instead of sewn and a duct stitch is unnecessary. Further study is needed to determine if drainage alone should be employed in grade 4 and 5 injuries.

POTENTIAL IMPACT OF ACA-RELATED INSURANCE EXPANSION ON TRAUMA CARE REIMBURSEMENT: COULD IT BE MORE THAN A BILLION DOLLARS?

John W. Scott MD,MPH, Pooja Upadhyaya BS, MPP, Peter Najjar MBA,MD, Kirstin W. Scott Ph.D., MPhil, David M. Cutler Ph.D., Ali Salim* MD, Adil H. Haider* MD,MPH, The Center For Surgery & Public Health, Brigham & Women's Hospital

Invited Discussant: L.D. Britt, MD, MPH

Introduction: Nearly one-quarter of trauma patients are uninsured and hospitals recoup less than 20% of inpatient costs for their care. This study aims to assess changes to hospital reimbursement for inpatient trauma care if the full coverage expansion provisions of the Affordable Care Act (ACA) had already been in effect.

Methods: Nonelderly adults (ages 18-64y) admitted for trauma were abstracted from the National Inpatient Sample (NIS) during 2010—the last year prior to most major ACA coverage expansion policies. National and facility-level reimbursements and trauma-related contribution margins were calculated using NIS-supplied cost-to-charge ratios and published reimbursement rates for each payer type: Medicare, Medicaid, private, uninsured, other. The pre-ACA expansion model used the observed payer-mix from the 2010 NIS; the post-expansion model used projections based on national census and income data to determine the proportion of currently uninsured patients that would be eligible to gain private insurance, gain Medicaid, or remain uninsured after full implementation of the ACA.

Results: A total of 145,120 patients (representing 734,921 patients nationwide) were included. National inpatient trauma costs totaled $13.8 billion (95%CI: 11.7-16.0). Pre-expansion reimbursements totaled $12.8 billion (10.8-14.7), yielding a national margin of -8.1% (-7.5,-9.2). Post-expansion projected reimbursements totaled $14.4 billion (12.0-16.4), increasing the margin by 11.8 absolute percentage-points to +3.7% (+3.0,+4.4) (**Table**). Of the 259 NIS-sampled facilities with at least 100 patient encounters in 2010, 85 (32.8%) had a positive trauma-related contribution margin in 2010, which would increase to 191 (73.7%) using post-expansion projections. Hospitals in the highest quartile of uninsured patients and those with >50% racial/ethnic minorities experienced the greatest hospital-level margin increases.

Conclusion: Coverage expansion for uninsured trauma patients has the potential to increase national reimbursement for inpatient trauma care by $1.6 billion and double the proportion of hospitals that see a positive margin on delivery of trauma care. These data suggest that insuring the uninsured a critical step to improving trauma centers' financially viability and their ability to provide life-saving care to the communities that they serve.

Table. Difference in trauma-related reimbursement after projected ACA insurance coverage expansion

	Pre-Expansion Model[1]		Post-Expansion Model[2]		Pre-/Post- Difference	
	Value	95% CI	Value	95% CI	Value	95% CI
Financial Estimates						
Inpatient Cost	$ 13.8 Billion	(11.7, 16.0)	$ 13.8 Billion	(11.7, 16.0)	--	--
Reimbursement[3]	$ 12.8 Billion	(10.4, 14.2)	$ 14.4 Billion	(12.0, 16.4)	$ 1.6 Billion	(1.2, 1.8)
Margin	-8.1 %	(-9.8%, -6.5%)	+3.7 %	(+3.0%, +4.4%)	+11.8 %	(+10.0%, +13.6%)

ACA, Affordable Care Act; *CI*, confidence interval
1. Pre-expansion model based on 2010 observed payer-mix from NIS for trauma patients of expansion eligible nonelderly adults (ages 18-64). Observed payer mix: 42.3% private, 9.1% Medicare, 15.1% Medicaid, 18.3% uninsured, and 15.1% other.
2. Post-expansion projection model based on Kaiser Family Foundation projections for nonelderly uninsured adults in which 53.3% will gain private coverage, 20.0% will gain Medicaid, and 26.7% will remain uninsured.
3. Derived from previously-published costs, reimbursements, and contribution margins for emergency and trauma care

PLATELET TRANSFUSIONS IN STANDARD DOSES DO NOT PREVENT LOSS OF PLATELET FUNCTION DURING HAEMORRHAGE

Paul Vulliamy MD, Scarlett Gillespie Ph.D., Karim Brohi* MD, Lewis Gall MD, Ross Davenport MD, Ph.D., Queen Mary University Of London
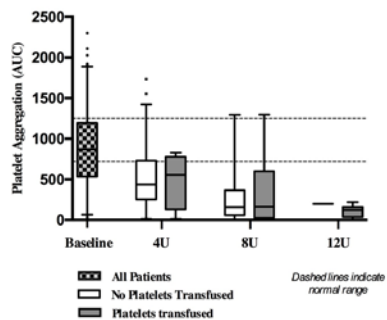
Invited Discussant: John Holcomb, MD

Introduction: Thrombocytes play a critical role in hemostasis with aberrant function implicated in trauma-induced coagulopathy. Transfusion of platelets to support both count and function is an integral component of hemostatic resuscitation. However, the impact of massive transfusion protocols on platelet function during trauma hemorrhage is unknown. The aim of this study was to characterize the effects of platelet transfusion on platelet aggregation during haemostatic resuscitation.

Methods: Trauma patients enrolled into the prospective Activation of Coagulation and Inflammation in Trauma (ACIT) study and receiving at least four units of packed red blood cells (PRBCs) were included in this study. Patients on antiplatelet therapy were excluded. Blood was drawn in the emergency department within 2 hours of injury and at intervals after every 4 units of PRBCs transfused, up to and including the 12th unit. Platelet aggregation in response to adenosine diphosphate, arachidonic acid, collagen and thrombin receptor activating peptide (TRAP) was assessed in whole blood with multiple electrode aggregometry (the Multiplate™ analyzer). Results are presented as median with interquartile range and compared using the Mann-Whitney U-test.

Results: Of 163 patients who received 4 or more PRBCs as part of their initial resuscitation, 44 received 8-11U and 28 received 12U or more. The median time from admission to platelet transfusion was 90 minutes (63-166). The average ratio of platelets to PRBCs, assuming one apheresis unit to be equivalent to 6U PRBCs, was 0.3 between 0-4PRBCs, 0.9 between 5-8PRBCs and 1.2 between 9-12PRBCs. In patients receiving platelet transfusions (n=107), platelet aggregation in response to stimulation with collagen decreased from 808U (IQR 554-1135) at baseline to 556U (131-778) after 4PRBCs, 163U (26-598) after 8PRBCs and 124U (37-159) after 12U (p<0.05 at each time-point compared to baseline, figure; normal range 720-1250U). A similar pattern was observed in response to the other three agonists. Patients who did not receive platelets had similar levels of aggregation in response to all four agonists during hemorrhage at each of the time-points studied (p>0.05 compared to patients receiving platelets). Platelet counts also decreased despite platelet transfusion, and were similar at each time-point compared to those not receiving platelets.

Collagen-induced platelet aggregation during bleeding and resuscitation

Conclusion: Current hemostatic resuscitation strategies do not appear to support platelet function during active haemorrhage. Platelet aggregation declines despite delivery of high ratios of apheresis platelets to PRBCs. Further investigation into the effects of 'up front' platelet transfusion on platelet function and clinical outcomes during bleeding are warranted.

RESULTS OF A MULTICENTER PROSPECTIVE PIVOTAL TRIAL OF THE FIRST IN LINE CONTINUOUS GLUCOSE MONITOR IN CRITICALLY ILL PATIENTS

Grant V. Bochicchio* MD,MPH, Stan Nasraway MD, Laura Moore* MD, Anthony Funary MD, Kelly Bochicchio RN, MSN Washington University School of Medicine

Invited Discussant: Dennis Kim, MD

Introduction: We have previously demonstrated that tight glycemic control (80-120 mg/dl) improves outcome in critically injured trauma patients. However, many centers have gotten away from aggressive glucose control due to the increased workload and risk of hypoglycemia. Our objective of this pivotal trial is to evaluate the first in human continuous inline glucose monitor (OptiScanner) in surgical critically ill and trauma patients.

Methods: A multicenter pivotal trial was conducted over a 1 year period (2014-2015) at 4 major academic centers. 200 critically ill patients admitted to SICU were enrolled. 3765 glucose measurements were obtained by the OptiScanner and then compared to the gold standard Yellow Springs Instrument (YSI). The scanner withdraws 0.13 ml of blood every 15 minutes from a central venous line, centrifuges the sample, and uses mid-infrared spectroscopy to measure glucose. We plotted a Clarke Error Grid, calculated Mean Absolute Relative Deviation (MARD) to analyze trend accuracy, and Population Coefficient of Variance (PCV). OptiScanner and YSI values were "blinded" from clinicians. Treatment was provided by the standard point of care meters.

Results: 95.4% of the data points were in zone A of the Clarke Error Grid and 4.5% in zone B. The MARD was 7.6%, the PCV 9.6%. The majority of data points achieved the benchmark for accuracy. The remaining 4.6% were clinically benign. The MARD was below 10%, which is the first continuous glucose monitor to achieve this result. The PCV was less than 10%, also a first. We confirmed that the OptiScanner outperformed every 1 to 3 hour glucose measurements using meters. This avoids glucose excursions and variability and achieves a higher time in normal range. There were no device related adverse events.

Conclusion: This pivotal multicenter trial demonstrates that the first inline CGM monitor is safe and accurate for use in in critically ill surgical and trauma patients.

FIBRINOLYTIC ACTIVATION IN PATIENTS WITH PROGRESSIVE INTRACRANIAL HEMORRHAGE EARLY AFTER TBI

Susan E. Rowell* MD, MCR, David H. Farrell Ph.D., Kelly Fair MD, Cole Hilliard BS, Elizabeth A. Rick BS, Belinda H. McCully, Ph.D., Rondi Dean BS, Amber Laurie Ph.D., Holly Hinson MD, Martin A. Schreiber* MD, Oregon Health & Science University

Invited Discussant: Mitchell Cohen, MD

Background: Progression of intracranial hemorrhage (PICH) is a significant cause of secondary brain injury in patients with traumatic brain injury (TBI). Coagulopathy is a major factor contributing to PICH and worse outcome after TBI yet the mechanism remains unclear. We sought to characterize the coagulation profile in patients with ICH to determine the relationship between specific coagulation pathways and PICH. We hypothesized that patients with PICH would have evidence of fibrinolytic activation that would be associated with an elevated LY30 on viscoelastic testing. **Methods**: We conducted a prospective observational study in adult trauma patients with isolated TBI (head AIS ≥ 3 and ≤ 2 in other regions). Blood was obtained for routine coagulation assays (INR, aPTT), platelet count, fibrinogen, protein C (PC), mediators of thrombin generation (thrombin-antithrombin complexes [TAT], prothrombin fragments 1+2 [F1+2]), mediators of fibrinolysis (D-dimer, plasminogen activator inhibitor-1[PAI-1], tissue plasminogen activator [tPA]) and soluble thrombomodulin (sTM) at admission, 6, 12, 24, and 48 hours. Thromboelastography (TEG) was performed at the same time points. A head CT was performed at admission and 6 hours in all patients and hemorrhage volumes were quantified. ICH progression was defined as a volume increase of at least 30%. Univariate analyses were performed to compare baseline characteristics between groups. Linear regression models were created adjusting for baseline differences between groups (age, gender, ISS, GCS, AIS head, aspirin use) to determine the relationship between individual assays and PICH. Median assay values were plotted over time based on progression status to characterize the temporal profile. **Results**: One hundred and sixty-four patients met entry criteria of which 91 progressed (55%). Patients with PICH were older (55[20] vs 47[22]), had a higher ISS (26[9] vs 19[9]) and AIS head (4[4 vs 5] vs 4[3 vs 4]), and a lower GCS (14[8-15] vs 14[14-15]). No other differences were observed. Patients with PICH had higher D-dimer during the first 24 hours (p<0.01at 0, 6, 12, 24 hrs) and higher tPA at 6 hours (p<0.01). sTM was lower at all time points in patients with PICH (p$\leq$0.05 at 0, 6, 12, 24, and 48 hours). No differences in other coagulation assays were observed. After adjusting for baseline differences, D-dimer remained elevated in patients with PICH compared to those without PICH at both admission (63% higher, p=0.03, 95% CI 6% to 150%) and 6-hours (50% higher, p=0.03, 95% CI 5% to 114% higher). No differences in LY30 were observed at any time point. The temporal profile of coagulation mediators plotted 48 hours after injury primarily demonstrated differences in mediators of the fibrinolytic pathway. D-dimer peaked at 6 hours and progressively decreased over 48 hours in PICH while remaining low at all time points in non-PICH. Both PAI-1 and tPA were highest at admission and demonstrated a 2-4 fold decrease in both groups over 48 hours. No trends were observed in the temporal profile of all other coagulation mediators. **Conclusion**: The association between PICH and elevated D-dimer early after injury suggest that fibrinolytic activation may in part be responsible for PICH in patients with TBI. The temporal changes observed in both tPA and PAI-1 support fibrinolytic activation and warrant further examination. Contrary to our hypothesis, fibrinolytic activation was not associated with increases in LY30.

REDEFINING THE CARDIAC BOX: EVALUATION OF THE RELATIONSHIP BETWEEN THORACIC GUNSHOT WOUNDS AND CARDIAC INJURY

Bryan C. Morse MD, MS, Rashi Jhunjhunwala BA, Michael J. Mina Ph.D., Elizabeth Roger BS, Christopher J. Dente* MD, Stacy D. Dougherty MD, Jeffrey M. Nicholas* MD, MS, Amy D. Wyrzykowski* MD, Rondi B. Gelbard MD, David V. Feliciano* MD, Emory University

Invited Discussant: Nicholas Namias, MD, MBA

Introduction: Injuries to the precordium raise concern for cardiac trauma especially for low energy stab wounds with a linear path. However, high energy missiles from gunshots can have a variable trajectory and deeper penetration raising concern for cardiac injury regardless of entrance site. The goal of this study is to assess the adequacy of the anatomic borders of the current "cardiac box" to predict cardiac injury. **Methods**: Retrospective review of trauma registry data of an urban level I trauma center was performed to identify patients with penetrating thoracic gunshot wounds and cardiac injury from 2011-2013. Using a circumferential grid system around the thorax (see figure), logistic regression analysis was first used to compare differences in rates of cardiac injury from entrance/exit wounds in the 'cardiac box' vs. the same for entrance/exit wounds outside the box. The process was then repeated to identify potential regions that yield improved predictions for cardiac injury over the current definition of the "cardiac box". **Results**: Over the 3-year study period, 263 patients sustained 735 penetrating thoracic wounds (89% male, mean age = 34 years, median injuries/person = 2), of which 80% were gunshot wounds (GSWs). After excluding stab wounds, 277 GSWs to the thorax included for study and 95 (34%) injured the heart. Of the 233 GSWs entering the cardiac box, 30% caused cardiac injury while, of the 44 GSWs outside the cardiac box, 32% penetrated the heart, suggesting that the current "cardiac box" is a poor predictor of cardiac injury relative to the thoracic non-"cardiac box" regions (OR 1.1; p=0.71; see Table). The regions from the anterior to posterior midline of the left thorax (regions 3-7, shaded dark gray) provided the highest positive predictive value (0.41) with high sensitivity (90%) and relatively high specificity (31%) while minimizing false positives making this region the most statistically significant discriminator of cardiac injury (OR 4.4; p=0.0001). Missile entrance wounds in zone 5 (left anterior-posterior axillary lines) had the highest individual odds ratio for cardiac injury (OR = 10.1; p=0.0001).

Regions (see figure)	OR	p-value	Sens.	Spec.	PPV
2,3,7,8 (Cardiac box)	1.1	0.7059	.85	.35	.35
2,3,4,5,6,7	6.1	0.0164	.98	.12	.37
3,4,5,6,7,8	9.1	0.0339	.99	.09	.36
3,4,5,6,7,10	4.3	0.0014	.94	.22	.39
3,4,5,6,7 (Improved box)	4.4	0.0001	.90		.41
3,4,5,7	3.6	0.0001	.86	.36	.41
2,3,5,6	3.3	0.0009	.88	.30	.40
2,3,5,7	2.6	0.0090	.88	.25	.38
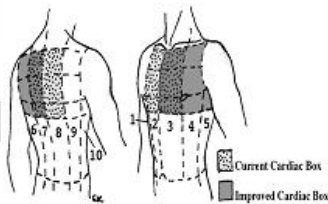
Conclusion: For GSWs, the current "cardiac box" was the poorest predictor of cardiac injury. We determine that the cardiac box should be redefined to include the area of the thorax that extends from the clavicle to xiphoid & from the anterior midline to the posterior midline of the left thorax. The classic cardiac box is inadequate to discriminate whether a GSW injury will create a cardiac injury.

NON-HUMAN PRIMATE (NHP) MODEL OF POLY-TRAUMATIC HEMORRHAGIC SHOCK RECAPITULATES EARLY PLATELET DYSFUNCTION OBSERVED FOLLOWING SEVERE INJURY IN HUMANS

Leasha J. Schaub MS, Andrew P. Cap MD, Ph.D., Jacob J. Glaser MD, Hunter B. Moore MD, Ernest E. Moore* MD, Forest R. Sheppard MD, Naval Medical Research Unit San Antonio

Invited Discussant: Weidun Guo, MD, PhD

Introduction: Platelet dysfunction has been described as an early component of trauma induced coagulopathy (TIC). The platelet component of TIC remains to be fully elucidated and translatable animal models are required to facilitate mechanistic investigations. Our objective was to determine if platelet dysfunction in a non-human primate (NHP) model of poly-traumatic hemorrhagic shock was consistent with that described in humans.

Methods: Rhesus macaques (n=24) underwent severe pressure targeted controlled hemorrhagic shock (PTCHS). A MAP of 20 mmHg was maintained for 1 hour (n=24), with either no additional injury (n=8), a soft tissue injury (ST, n=8), or ST and musculoskeletal injury (ST-MS, n=8) introduced. After 1 hour, resuscitation with 0.9% NaCl and whole blood was initiated. Platelet counts and Multiplate ® assays were performed at baseline (BSLN), end of shock (T=1hr), end of resuscitation (T=3hr), and T=6hr. Results reported as mean±SEM, Stats: Spearmen correlation and One-way RM-ANOVA with p<0.05 significant.

Results: Platelet count in all injury groups decreased over time. Weak correlations were observed between platelet response and platelet count for all agonists: adenosine diphosphate (ADP, r=0.5252, p<0.0001), thrombin recognition activating peptide-6 (TRAP, r=0.5381, p<0.0001), collagen (COL, r=0.4718, p<0.0001), and arachidonic acid (AA, r=0.4718, p<0.0001). Overall, compared to BSLN: platelet response decreased for ADP at T=1hr, all agonist at T=3hr, and for ADP, COL, and AA at T=6hr. Between T=1hr and T=3hr, impaired platelet response was observed for COL and AA. While evaluating the effect of injury severity in combination of shock, specific platelet dysfunction patterns were elucidated over time.
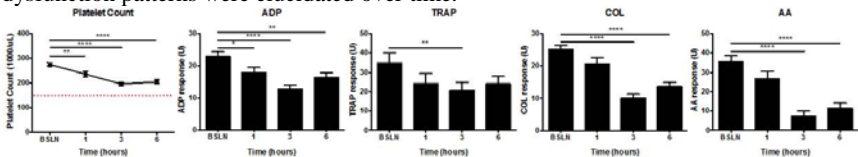
Conclusion: NHPs manifest early platelet dysfunction in response to hemorrhagic shock and tissue injury, which has been observed in severely injured human patients. Additionally, the pattern of injury modifies the effect of specific platelet dysfunction independent of platelet count. NHP models provide a valuable translatable model for understanding the pathophysiology of trauma induced platelet inhibition and additional investigation is underway using NHP models.

AUTOMATED VARIABLE AORTIC CONTROL VS. COMPLETE AORTIC OCCLUSION IN A SWINE MODEL OF HEMORRHAGE

Timothy K. Williams MD, Lucas P. Neff MD, Michael A. Johnson MD, Ph.D., Hilary B. Loge MD, Anders J. Davidson MD, Sarah-Ashley Ferencz MD, Rachel M. Russo MD, Nathan F. Clement MD, John K. Grayson Ph.D., DVM, Todd E. Rasmussen* MD, Clinical Investigation Facility, David Grant Medical Center

Invited Discussant: Thomas Scalea, MD

Introduction: Future endovascular hemorrhage control devices will require features that mitigate the adverse effects of vessel occlusion. Variable aortic control (VAC) is a new approach that adjusts distal aortic perfusion (DAP), minimizes hemorrhage and reduces the ischemic burden of complete aortic occlusion (AO). The objective of this study was to introduce the concept of automated VAC and compare it to (AO) in a lethal model of hemorrhage.

Methods: Twenty-five swine underwent division of the supraceliac aorta - complete aortic occlusion - with diversion of DAP through an automated extracorporeal circuit. After creation of uncontrolled liver bleeding, animals were randomized to 90 minutes of treatment: Control (full, unregulated DAP; n=5), AO (no DAP; n=10), and VAC (regulated DAP initiated after 20 minutes of AO; n=10). In the VAC group, DAP rates were regulated between 100-300mL/min based on a desired, preset range of proximal mean arterial pressure (MAP). At 90 minutes, damage control surgery, resuscitation, and restoration of full DAP ensued. Critical care continued for 4.5 hours or until death. Hemodynamic parameters and markers of ischemia were recorded.

Results: Study survival was 0%, 50%, and 90% for control, AO, and VAC respectively (p<0.01) (Figure). During intervention, VAC resulted in lower proximal MAP (84mmHg±18 vs. 104±8mmHg, p<0.01), but higher renal blood flow than AO animals (p=0.02). During critical care, VAC resulted in higher proximal MAP (73 mmHg±8 vs. 50 mmHg±6, p<0.01), carotid and renal blood flow (p<0.01), lactate clearance (p<0.01), and urine output (p<0.01) than AO despite requiring half the amount of fluid to maintain proximal MAP ≥50 mmHg (p<0.01). Incidence of spinal cord ischemia was 3-fold higher in animals with AO compared to those with VAC.

Kaplan-Meier Survival Estimates
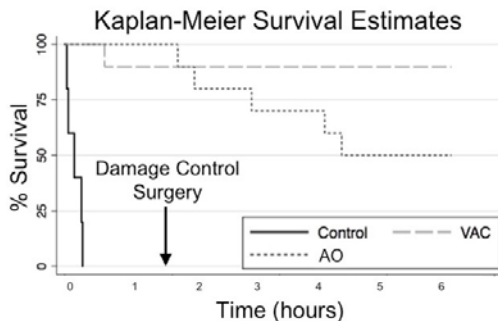
Conclusion: Automated distal perfusion beyond complete aortic occlusion minimizes the adverse effects of distal ischemia, optimizes proximal pressure to the brain and heart and prevents exsanguination in this model of lethal hemorrhage. These findings provide foundational knowledge from which step-change technologies in automated, endovascular bleeding control can be assembled.

LONG-TERM OUTCOMES OF THORACIC ENDOVASCULAR AORTIC REPAIR (TEVAR): A SINGLE INSTITUTION'S 11-YEAR EXPERIENCE

Megan Brenner* MD, MS, William Teeter MD, Muhammad Hadhud Melanie Hoehn MD, James O'Connor* MD, Deborah Stein* MD, MPH, Thomas Scalea* MD, University of Maryland Medical Center

Invited Discussant: Demetrios Demetriades, MD, PhD

Introduction: TEVAR has largely replaced traditional open aortic repair for anatomically suitable lesions, however, long-term outcomes are unknown.

Methods: All patients who underwent TEVAR from December 2004-October 2015 at a single tertiary care institution were included. Demographics, injury pattern, operative details, outcomes, and surveillance were reviewed. Follow-up ranged from 2-132 months, and was obtained from clinic notes and imaging reports.

Results: A total of 88 patients underwent TEVAR; all suffered from blunt mechanisms, 72.7% were male. Median age, ISS, TRISS was 47(19.7), 38(13.5), 0.8(0.34). Injuries included 2% grade II, 90% grade III, 8% grade IV. Median ventilator, hospital, and ICU days were 7[3,17], 16.8[8.5,24], and 12.3[5,20]. Overall mortality was 6.8% due to intra-abdominal sepsis (1.1%), cardiac arrest (2.3%), grade 5 liver injury (1.1%), and TBI (2.3%). TEVAR-related mortality was 0%. Overall in-hospital complication rate was 57%. TEVAR-related complication rate was 9.1%: 4 type 1a endoleaks, 2 type 2, and 2 type 3. Of the type 1 endoleaks, all required re-operation, while all type 2 and 3 endoleaks resolved on subsequent imaging. Of the type 1a endoleaks, 1 required proximal extension only, 1 required proximal extension and a left subclavian-carotid artery (LSCA) bypass, and 2 required conversion to open repair despite proximal graft extension. No re-intervention for endoleak was required after TEVARs performed beyond 2009. The left subclavian artery (LSA) was intentionally covered at index operation in 19 patients (21.6%), and 7 patients (8%) had partial LSA coverage. The rate of post-operative left upper extremity ischemia was 0%, and LSCA bypasses were performed prophylactically in 2 patients prior to LSA coverage at index operation. 87% of endograft access was by performed by open femoral artery exposure and 1.1% via retroperitoneal conduit. Percutaneous TEVAR (pTEVAR) for device access was performed more recently in 11.4% of patients with no complications. Heparin was administered intra-operatively in 23 patients with TBI, and 12 patients were not heparinized; no adverse events or outcomes resulted from its use or lack thereof. 66 patients were discharged to rehabilitation centers and 16 patients discharged directly to home. First, second, and third surveillance imaging occurred at mean intervals of 14 days, 4 months, and 1 year, respectively. The longest imaging surveillance was at 8 years, 11 months and 7 days from index operation. Percent of patients followed at 1, 3, 5 years from operation was 62.1%, 25%, 13.6%. The median interval from index operation to most recent imaging was 522 [237, 1127] days (range 4 to 3262 days).

Conclusion: TEVAR continues to be a feasible treatment modality for blunt traumatic aortic injury with few and early TEVAR-specific complications. Device related complications have been significantly reduced as a result of improvements in technology and experience. Follow-up continues to be a significant challenge in this population, and protocols for surveillance imaging are needed. This is the first study to describe short and long term outcomes of pTEVAR exclusively in trauma patients. Long-term outcomes of TEVAR are at least comparable to open repair 11 years after initial intervention.

Potential contribution of mitochondrial (mt) DNA Damage Associated Molecular Patterns (DAMPs) in transfusion products to development of the Acute Respiratory Distress Syndrome (ARDS) after multiple transfusions

Jon D. Simmons* MD, Viktor M. Pastukh MS, Gina Capley MS, Cherry A. Muscat BS, David C. Muscat BS, Michael L. Marshall BS, Sidney B. Brevard* MD, Mark N. Gillespie Ph.D., University of South Alabama

Invited Discussant: Carl Hauser, MD

Introduction: Observations in the combat casualty management arena suggest that transfusion protocols including equal amounts of packed red blood cells (PRBC) and fresh frozen plasma (FFP), although decreasing acute mortality, are accompanied by an increased incidence of a particularly aggressive and lethal form of acute lung injury (TRALI). The mechanism of delayed TRALI in this setting is unknown, and numerous previous studies have failed to identify potential initiating factors. In light of recent reports showing that mtDNA DAMPs are potent pro-inflammatory mediators, and that their abundance in the sera of severely injured or septic patients is predictive of clinical outcomes, we explored the idea that mtDNA DAMPs are present in transfusion products and are associated with the occurrence of TRALI. **Methods**: We used qPCR to quantify selected 200 bp sequences of extracellular mtDNA in PRBCs, FFP, and platelets. Next, we enrolled fifteen consecutive severely injured patients that received greater than three units of blood transfusion products and determined if the total amount of mtDNA DAMPs delivered during transfusion was correlated with the serum mtDNA measured immediately after the last transfusion, and whether the quantity of mtDNA DAMPs in the serum predicted development of ARDS. **Results**: We found detectable levels of mtDNA DAMPs in PRBCs (3 ± 0.4 ng/mL) , FFP (213.7 ± 65 ng/mL) , and platelets (94.8 ± 69.2) , with the latter two transfusion products containing significant amounts of mtDNA fragments (Figure-left). The abundance of mtDNA fragments in blood components from Type A donors was significantly more than the others (Figure-middle). There was a linear relationship between the mtDNA DAMPs given during transfusion and the serum concentration of mtDNA fragments ($R^2=0.8$, $p<0.01$). The quantity of mtDNA DAMPs in serum measured at 24 hours after transfusion predicted the occurrence of ARDS (9.9 ± 1.4 vs 3.3 ± 0.9, $p<0.01$, Figure-right). **Conclusion**: These data show that FFP and platelets contain large amounts of extracellular mtDNA, that the amount of mtDNA DAMPs administered during transfusion may be a determinant of serum mtDNA DAMP levels, and that serum levels of mtDNA DAMPs after multiple transfusions may predict the development of ARDS. Collectively, these findings support the idea that mtDNA DAMPs in transfusion products significantly contribute to the incidence of ARDS after massive transfusions. Furthermore, these data may also suggest that blood components from blood type A donors are more inflammatory than other ABO blood types.
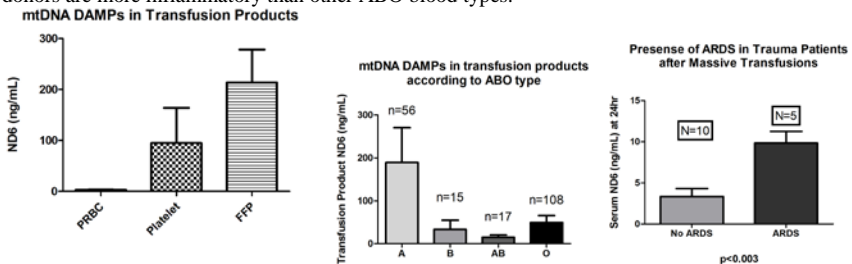
LONGITUDINAL ANALYSIS OF CIRCULATING MITOCHONDRIAL DNA AS A BIOMARKER IN PATIENTS WITH SYSTEMIC INFLAMMATORY RESPONSE SYNDROME

Mehreen Kisat MD, Bellal Joseph* MD, Tania Contente-Cuomo BS, Zain Khalpey MD,Ph.D., Paul Keim Ph.D., Muhammed Murtaza MD,Ph.D., Peter Rhee* MD, University of Arizona – Tucson

Invited Discussant: Lawrence Diebel, MD

Introduction: Circulating mitochondrial DNA (mtDNA) levels are elevated in animal models of sepsis. However, the diagnostic utility and clinical role of mtDNA in patients with systemic inflammatory response syndrome (SIRS) is debated and data on serial changes in mtDNA are limited. We hypothesized that longitudinal analysis of circulating mtDNA levels in patients with SIRS or sepsis will correlate with clinical course.

Methods: We conducted a prospective study of 30 consecutive patients suspected of sepsis in the Surgical Trauma ICU and compared with 22 healthy volunteer controls. Longitudinal plasma samples were collected at the time of workup for sepsis (day 0) and on days 7 and 14. Blood samples were collected in Streck Cell-Free DNA tubes and processed within 24 hours. DNA was extracted using QIAamp Circulating Nucleic Acid Kit. We measured mtDNA levels in plasma using real-time quantitative PCR targeting the mitochondrial NADH1 gene. Absolute mtDNA copies were calculated by comparing with known standards, pre-quantified using droplet digital PCR. mtDNA levels were log-transformed and compared between groups using Student t-test. Correlation between mtDNA and clinical parameters was explored using multivariate linear regression.

Results: We analyzed 72 serial plasma samples from 30 patients with suspected sepsis. Median mtDNA levels in controls were 602 ± 636 copies/μL of plasma (median ± IQR). In comparison, median mtDNA levels at day 0 in patients with SIRS were 3330 ± 2626 copies/μL (Figure 1, $p<10^{-8}$, area under the ROC curve: 0.936). mtDNA levels were correlated with peripheral WBC count after adjusting for heart rate and temperature (Figure 2, p=0.008). mtDNA levels were elevated in patients with septic shock (systolic BP < 90 mm Hg, p=0.020). In this cohort, 3/30 patients died within the same hospital stay and last recorded mtDNA levels were higher as compared to survivors (Figure 3, p=0.012).

Conclusion: Circulating mtDNA levels in patients with suspected sepsis are five-fold higher than healthy controls. Longitudinal changes in mtDNA are correlated with conventional markers of systemic inflammatory response and can be a biomarker for outcomes.

Figure 1 — Patients vs. controls

Figure 2 — WBC count vs. mtDNA levels in patients

Figure 3 — Survivors vs. Non-survivors
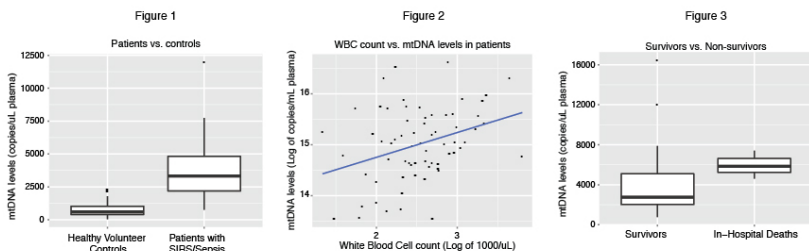
HEMORRHAGIC SHOCK DEPLETES AVP STORES AND HORMONAL SUPPLEMENTATION PRESERVES MITOCHONDRIAL FUNCTION

Carrie Sims* MD, Yuxia Guan BS, Evan Werlin MD, Patrick Reilly* MD, University of Pennsylvania

Invited Discussant: Jason Smith, MD

Introduction: Arginine vasopressin (AVP), a hormone secreted by the posterior pituitary, plays an important role in maintaining vasomotor tone during acute blood loss. We hypothesized that hemorrhagic shock results in decreased AVP stores and supplementation during resuscitation would improve blood pressure and renal function.

Methods: Male Long-Evans rats were bled to MAP 40mmHg & maintained until the MAP could not be sustained without fluid. Once 40% of the shed volume (40%SVT) was returned in LR, animals were resuscitated over 60min w/4x the shed volume in LR or the same fluids w/AVP (0.5 U/kg+2 U/kg/hr). Animals (n=5/group) were sacrificed before hemorrhage (Sham), at 40%SVT, following resuscitation (60R, 60R w/AVP) or 18hrs post-resuscitation (18hr, 18hr w/AVP). Pituitaries were harvested and assayed for AVP. Kidney samples were taken to assess mitochondrial function, histology, and oxidative damage. Blood samples were taken to measure AVP levels and renal function.

Results: Baseline pituitary AVP stores (25,606±8894 pg/ml) decreased with severe shock (18,887 ±5,317 pg/ml) and were significantly depressed 18 hrs post resuscitation (9132 ±1486 pg/ml, $p<0.05$). Resuscitation with LR+AVP led to higher serum AVP levels at 60R (31±8 vs 79±12; $p<0.01$) with an improved MAP at 60R (125±3 vs 77±7mmHg;$p<0.01$) and 18hr (82±6 vs 69±5mmHg;$p<0.05$). AVP supplementation preserved complex I respiratory capacity at 60R (103±4 vs 85±5 nmolesO2/min/mg;$p<0.05$) and at 18hrs (98 ±5 vs 80 ±6 nmolesO2/min/mg;$p<0.05$). AVP was also associated with decreased ROS generation at 60R (856±67 vs 622±48F FU) and significantly decreased oxidative damage as measured by mitochondrial lipid peroxidation (0.9±0.1 vs 1.7±0.1 fold change, $p<0.01$) and nitrosylation (0.9±0.1 vs 1.4±0.2 fold change,*$p<0.05$-relative to sham). Although AVP was associated with improved renal histologic architecture at 18hrs, it did not significantly change BUN or creatinine levels.

Conclusions: Pituitary AVP stores decrease following severe hemorrhagic shock and resuscitation. Supplementation with AVP improves blood pressure, preserves renal mitochondrial function and decreases oxidative damage.

SYSTEMIC ANTICOAGULATION IN THE SETTING OF VASCULAR EXTREMITY TRAUMA

Melissa N. Loja MD, MAS, Andrew Wishy DO, Misty Humphries MD, Stephanie Savage* MD, MS, Timothy Fabian* MD, Thomas Scalea* MD, John B. Holcomb* MD, Nathaniel Poulin* MD, Joseph M. Galante* MD, Todd E. Rasmussen* MD, AAST PROOVIT Study Group * University of California, Davis

Invited Discussant: David Feliciano, MD

Introduction: There is conflicting data regarding if patients with vascular extremity trauma who undergo surgical treatment need to be systematically anticoagulated. We hypothesized that intraoperative systemic anticoagulation (ISA) does not change the risk of repair thrombosis or limb amputation after traumatic vascular injury of the extremities.

Methods: We analyzed a composite risk of repair thrombosis and/or limb amputation (RTLA) between patients who did and did not undergo ISA and arterial injury repair. Patient data was collected in the AAST PROspective Vascular Injury Treatment (PROOVIT) registry. This registry contains demographic, diagnostic, treatment, and outcome data on patients admitted to one of 14 Level 1 trauma centers, collected prospectively. Multivariate logistic regression analysis was utilized to determine independent risk factors for RTLA. Clinically relevant variables incorporated into the model included age, gender, AIS extremity, concomitant nerve or vein injury, injury location, post-operative antiplatelet or anticoagulation, and type of arterial repair.

Results: Between February 2013 and August 2015, 193 patients with upper or lower extremity arterial injuries who underwent open operative repair were entered into the PROOVIT registry. The majority were male (86%) with a mean age of 32.6 years (range 4-91) and 73.5% injured by penetrating mechanism. 62.6% of the injuries were described as arterial transection and 36.7% had concomitant venous injury. 61.6% of patients underwent ISA. RTLA occurred in 22 patients (11.4%) overall, with no significant unadjusted difference in these outcomes between patients who received ISA and those that did not (12 versus 10, p = 0.445). On multivariate logistic regression analysis, ISA did not prove an independent predictor of RTLA. There was, however, significantly higher total blood product use noted among patients treated with ISA versus those that did not receive ISA (5.5 [4.09-6.90] vs. 3.7 [1.58-5.81], p = 0.003). There were no deaths in the total cohort.

Discussion: In this multicenter prospective cohort, intraoperative systemic anticoagulation was not associated with a difference in rate of repair thrombosis or limb loss; but was associated with an increase in blood product requirements. Our results suggest that the use of systemic anticoagulation does not change the risk of repair thrombosis or amputation after repair of arterial injuries.

RESULTS OF A REGIONAL COLLABORATIVE QUALITY INITIATIVE FOR TRAUMA

Mark R. Hemmila* MD, Jill L. Jakubus PA-C, Anne H. Cain-Nielsen MS, John P. Kepros MBA, MD, Michael McCann DO, Wayne E. Vander Kolk MD, Wendy L. Wahl* MD, Judy N. Mikhail Ph.D., RN, University of Michigan

Invited Discussant: Oscar Guillamondegui, MD, MPH

Introduction: Trauma centers and a third party payer within our state built a regional collaborative quality initiative (CQI). This CQI program began as a pilot in 2008 and expanded to a formal program in 2011. Here, we examine the performance of the collaborative over time with regard to patient outcomes, resource utilization, and process measures.

Methods: Data from the initial 23 hospitals that joined the CQI in 2011 were analyzed. Baseline performance was established using the 2011 data. Comparisons were made to unadjusted results achieved in 2014 by the same 23 trauma centers. Risk-adjustment was performed to confirm results observed in the unadjusted data. The relative change in performance from 2011 to 2014 was calculated and is expressed as a percentage decrease or increase. P-values were calculated using chi-squared tests for binary outcomes and t-tests for continuous outcomes. To calculate the number of patients impacted by the CQI program, the relative change was multiplied by the number of trauma patients treated in the 23 hospitals during 2014.

Results: Membership in a CQI program significantly reduced complications and improved process measure execution in trauma patients over four years' time (Table). Similar results were obtained in unadjusted and risk-adjusted analyses. The CQI decreased serious complications by 138 patients/year, eliminated 1,014 mechanical ventilator days, and avoided prophylactic IVC filter placement in 165 patients annually.

Measure	Base Rate	2014 Rate	Relative Change (%)	p-value
Mortality (%)	5.37	5.03	- 6.3	0.3
Serious Complication (%)	8.57	7.37	- 14.0	0.001
Pneumonia (%)	4.29	3.46	- 19.3	0.001
Severe Sepsis (%)	0.92	0.60	- 34.8	0.005
Venous Thromboembolism (%)	1.87	1.27	- 32.1	<0.001
Urinary Tract Infection (%)	3.47	1.75	- 49.6	<0.001
Mechanical Ventilator Days	7.7 ± 10.4	6.8 ± 8.5	- 11.7	0.006
VTE Prophylaxis Initiated ≤ 48 hrs (%)	38.2	47.8	+ 25.1	<0.001
VTE Prophylaxis with LMWH (%)	30.1	36.1	+ 19.9	<0.001
Prophylactic IVC Filter Placement (%)	2.53	1.10	- 56.5	<0.001

Conclusion: This study confirms our hypothesis that participation in a regional collaborative quality initiative improves trauma patient outcomes and decreases resource utilization while promoting compliance with processes of care.

NEURO-, TRAUMA-, OR MED/SURG-ICU: DOES IT MATTER WHERE POLYTRAUMA PATIENTS WITH TBI ARE ADMITTED? SECONDARY ANALYSIS OF THE AAST-MITC DECOMPRESSIVE CRANIECTOMY STUDY.

Sarah Lombardo MD, D Millar MD, Thomas Scalea* MD, Lou Magnotti* MD, Gregory J. Jurkovich* MD, Gary Vercruysse* MD, Jason Sperry* MD,MPH, Kathryn Beauchamp MD, Iman Feiz-Erfan Patrick O'Neill* MD, Raul Coimbra* MD, Ram Nirula* MD,MPH, University of Utah

Invited Discussant: Jennifer Gurney, MD

Introduction: Patients with non-traumatic acute intracranial pathology benefit from neurointensivist care. Similarly, trauma patients with and without TBI fare better when treated by a dedicated trauma team. No study has yet evaluated the role of specialized neurocritical (NICU) and trauma intensive care units (TICU) in the management of TBI patients, and it remains unclear which TBI patients are best served in NICU, TICU, or general (Med/Surg) ICU.

Methods: Twelve Level 1 trauma centers provided clinical data and head CT scans of patients with Glasgow Coma Scale (GCS) ≤13 and CT evidence of TBI. Non-ICU admissions were excluded. Multivariate logistic regression was performed to measure the association between ICU-type and survival and calculate the probability of death for increasing ISS. Polytrauma patients (ISS > 15) with

Fig 1.P(Death) for polytrauma-TBI by unit type & ISS

TBI and isolated TBI patients (other AIS<3) were separately analyzed.
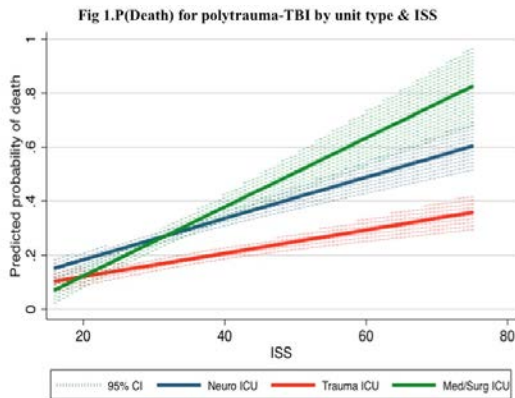
Results: There were 3641 patients with CT evidence of TBI with 2951 admitted to an ICU. Prior to adjustment, patient demographics, injury severity, and survival differed significantly by unit type. After adjustment, unit-type, age and ISS remained independent predictors of death (Figures 1 and 2). Unit-type modified the effect of ISS on mortality. TBI-polytrauma patients admitted to a TICU had improved survival across increasing ISS (Fig1). Survival for isolated TBI patients was similar between TICU and NICU. Med/Surg ICU carried the greatest probability of death (Fig2).

Conclusion: Polytrauma patients with TBI have lower mortality risk when admitted to a Trauma ICU. This survival benefit increases with increasing injury severity. Isolated TBI patients have similar mortality risk when admitted to a Neuro ICU compared to a Trauma ICU. Med/Surg ICU admission carries the highest mortality risk.

THE TRAUMA ECOSYSTEM: THE ECONOMICS AND IMPACT OF NEW TRAUMA CENTERS ON EXISTING CENTERS

David J. Ciesla* MD, Etienne E. Pracht Ph.D., Pablo T. Leitz MD, David A. Spain* MD, Kristan L. Staudenmayer* MD, University of South Florida

Invited Discussant: Robert Winchell, MD

INTRODUCTION: There is evidence that the establishment of new trauma centers in proximity to existing ones creates economic strain for the original centers; however, this has only been studied in single-center settings. Florida has a mature statewide trauma system and serves as a model for the study of system development. In 2010 there were 7 Adult Level I and 13 Level II Florida trauma centers. An additional 5 Level II trauma centers were designated in 2012. We hypothesized that changes in payer mix and total inpatient charges would be associated with the establishment of new centers close to existing trauma centers.

METHODS: A statewide discharge dataset was queried for all injury related discharges from adult acute care hospitals using ICD-9 codes for 2010 and 2014. Inclusion criteria and definitions of high-risk injury were chosen to match those used by the Florida department of health in its trauma registry. Hospitals were classified as existing Level I (E1) or Level II (E2) trauma centers and New Level II (N2) centers.

RESULTS: Five N2 centers were established 21-107mi from existing centers. Excluding one center 107mi distant, the range was 21-40mi (average 32mi). In 2014 36% were treated at E1, 43% at E2 and 21% at N2. Despite fewer patients, 30% of all trauma charges originated in the 5 N2 centers (36% in 7 E1 and 34% in 13 E2). Total charges increased for E1 centers by $193 million (12%), for E2 by $371 million (28%), and for N2 by $1.1 billion (319%). Payer mix proportions changed from .13/.66/.22 Self/Medicare-Medicaide/Commercial to .16/.54/.30 at N2, from .20/.38/.42 to .20/.43/.37 at E1 and from .13/.50/.37 to .11/.55/.35 at E2.

CONCLUSION: Most new trauma centers were established within 40 miles of an existing Level I or II trauma center. After new centers were established, there was an associated decrease in the number of patients and charges to commercial payers at existing centers. These findings suggest that the health of an entire trauma system must be considered prior to the establishment of new trauma centers.

Change in Payer Mix for FL Level I&II Trauma Centers, 2010 to 2014
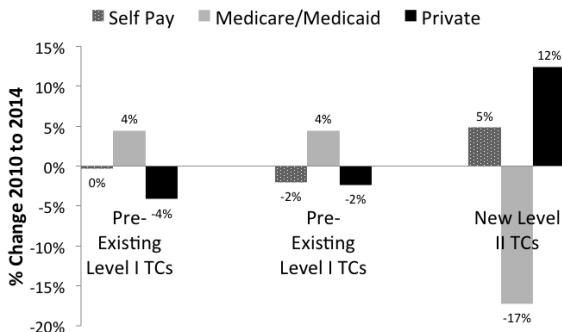
THE AIR MEDICAL PREHOSPITAL TRIAGE SCORE: EXTERNAL VALIDATION SUPPORTS ABILITY TO IDENTIFY INJURED PATIENTS THAT WOULD BENEFIT FROM HELICOPTER TRANSPORT

Joshua B. Brown MD, MSc, Mark L. Gestring* MD, Francis X. Guyette MD, MPH, Matthew R. Rosengart* MD, MPH, Nicole A. Stassen* MD, Raquel M. Forsythe* MD, Timothy R. Billiar* MD, Andrew B. Peitzman* MD, Jason L. Sperry* MD, MPH, University of Pittsburgh

Invited Discussant: Jay Doucet, MD, MSc

Introduction: The Air Medical Prehospital Triage (AMPT) score was recently developed to help EMS providers identify injured patients in the field who benefit from helicopter EMS (HEMS) transport to a trauma center from the scene of injury. The AMPT score was developed using the NTDB, however external validation using a different dataset is essential to ensure reliable performance of the score. The Pennsylvania Trauma Outcomes Study (PTOS)

TABLE 1. Air Medical Prehospital Triage Score

Criterion	Points
Glasgow Coma Scale <14	1
Respiratory Rate <10 or >29 breaths/min	1
Unstable chest wall fractures	1
Suspected hemothorax or pneumothorax	1
Paralysis	1
Multisystem trauma (>2 body regions injured)	1
Any physiologic + any anatomic criterion from National Field Triage Guidelines	2

Consider helicopter transport if AMPT score ≥2 points

registry was selected for this purpose as it offered the ability to critically evaluate the AMPT score with a different case-mix, time period, and more granular trauma dataset. The objective of this study was to validate the effectiveness of the AMPT score to identify patients with a survival benefit from HEMS transport using the PTOS registry.

Methods: Patients age ≥16yrs transported from the scene by HEMS or ground EMS (GEMS) in the PTOS registry 2000-2013 were included. The AMPT score was calculated for each patient, and patients with ≥2 points were triaged to HEMS transport, while those with <2 points were triaged to GEMS transport (Table 1). The primary outcome was in-hospital survival. Multilevel logistic regression determined the association of survival with actual transport mode (HEMS vs GEMS), adjusting for demographics, mechanism, vital signs, EMS interventions, injury severity, transfusions, surgery for hemorrhage, and complications. The model was applied separately in patients triaged to HEMS and those triaged to GEMS by the AMPT score. Successful validation was defined as a survival benefit for actual HEMS transport in patients triaged to HEMS by the AMPT score, with no association between survival and actual transport mode in patients triaged to GEMS by the AMPT score. Subgroup analyses were performed in patients treated by only advanced life support (ALS) providers and patients with transport times >10mins.

Results: 222,827 patients were included with 44,351 (20%) undergoing HEMS transport. Overall, 24,328 (11%) of patients were triaged to HEMS transport by the AMPT score. For patients triaged to GEMS transport by the AMPT score (0 or 1 point), actual transport mode was not associated with survival (AOR 1.00; 95%CI 0.82—1.22, p=0.97). For patients triaged to HEMS transport by the AMPT score (≥2 points), actual transport by HEMS was associated with a 31% increase in the odds of survival (AOR 1.31; 95%CI 1.06—1.61, p=0.01). All subgroups had similar results (Table 2).

Conclusion: This study is the first to externally validate the AMPT score, demonstrating the ability of this tool to correctly and reliably identify trauma patients most likely to benefit from HEMS transport. The AMPT score should be considered when protocols for HEMS scene response are developed and reviewed.

TABLE 2. Subgroup survival by actual transport mode (HEMS v GEMS)

Subgroup	AOR	95%CI	p value
ALS providers only			
Triaged to GEMS by AMPT	0.99	0.82 – 1.19	0.90
Triaged to HEMS by AMPT	1.31	1.06 – 1.61	0.01
>10-minute transport time			
Triaged to GEMS by AMPT	0.98	0.79 – 1.22	0.89
Triaged to HEMS by AMPT	1.28	1.02 – 1.60	0.03
ALS providers only and >10-minute transport time			
Triaged to GEMS by AMPT	0.97	0.79 – 1.19	0.77
Triaged to HEMS by AMPT	1.29	1.03 – 1.61	0.03

ACS NEEDS BASED ASSESSMENT OF TRAUMA SYSTEMS (NBATS) TOOL: CALIFORNIA EXAMPLE

Tarsicio Uribe-Leitz MD,MPH, Micaela M. Esquivel MD, Naomi Y. Garland MD,MPH, Lisa M. Knowlton MD,MPH, Lakshika Tennakoon MD, Timothy Browder MD, Paul Maggio* MBA,MD, Renee Y. Hsia MD, MSc, Thomas G. Weiser MD,MPH, David Ciesla* MD, David A. Spain* MD, Robert J. Winchell* MD, Kristan L. Staudenmayer* MD, MS Stanford University

Invited Discussant: Michael Rotondo, MD

Introduction: A goal of trauma systems is to best match resources to population need. In 2015, the American College of Surgeons Committee on Trauma convened a consensus conference to develop the Needs Based Assessment of Trauma Systems (NBATS) tool to assist in determining the number of trauma centers (TCs) required for a region. This tool is still being optimized, and has not yet been evaluated. We used the current draft NBATS tool to test the performance of the model with respect to the optimal number of TCs needed by region in California. We hypothesize that the NBATS tool will differentiate between regions based on estimated need.

Methods: We obtained TC data and population data from the California Emergency Services Authority. Numbers of admitted trauma patients (ISS >15) were obtained using statewide non-public admissions data from the California Office of Statewide Health Planning and Development (OSHPD). We used Local Emergency Medical Service Agency (LEMSA) for regional trauma service areas. Spatial analyses were done in ArcGIS to geocode median transport times based on existing road networks. NBATS criteria used included population, transport time, community support, and number of discharges for severely injured patients (ISS >15) at non-TCs. This score was adjusted depending on the presence and use of Level I- III TCs.

Results: A total of 74 designated TCs were identified for California-- 15 (20.3%) Level I, 37 (50%) Level II, 14 (18.9%) Level III and 8 (10.8%) Level IV. According to the NBATS scoring system, four (12.1%) LEMSAs had an adequate number of TCs, and 26 (78.8%) had scores that suggesting that additional trauma centers were needed. Of these regions, 9 (27.3%) would require 1 additional TC, thirteen (39.4%) would require 2 additional TCs, and 4 (12.1%) would require 3 more TCs. In 3 LEMSAS (9.1%), the model suggested there were already more TCs than required.

Conclusion: To our knowledge, this is the first application of the NBATS tool to a statewide trauma system, using data available to the lead agency. We propose the use of GIS methodology as way to refine the access parameters of the model. The tool identified regions that would require additional TCs. Just as importantly, it identified regions that required no further TCs and 3 regions with more TCs than predicted by the model. While the NBATS tool requires development, validation, and further study, results from the current study suggest the tool may be helpful in the characterization and assessment of statewide trauma needs.

Compliance with Triage Directions from an Organized State Trauma Communication Center Improves Trauma Patient Outcomes

Benjamin R. Martinez MD, Shoichiro Tanaka MD,MPH, Margaret Moore MD, Patrick Greiffenstein MD, John T. Owings* MD, FACS, John P. Hunt* MD,MPH, Chris Hector NRP, Paige Hargrove RN, BSN LSU Department of Surgery

Invited Discussant: Robert Mackersie, MD

Background: The Louisiana Emergency Response Network (LERN) is a state agency created by the State Legislature in 2004. Its purpose is to develop and maintain a statewide system to triage patients with "time-sensitive illness" (myocardial infarction, stroke, and trauma) and oversee disaster preparedness. Trauma was LERN's first "time sensitive illness" for which around-the-clock hospital destination data were provided. LERN has a single communication center (LERN-CC) that takes all calls from pre-hospital and hospital providers from the entire state and identifies the most appropriate destination for their patient. In 2014 the LERN trauma triage protocol was essentially the same as the CDC trauma triage protocol. The medics staffing LERN's communications center provided direction based on this protocol. The purpose of our study was to compare outcomes between those patients who complied with the LERN triage protocol and those who did not.

Methods: All patients entered into the LERN database as trauma patients and given pre-hospital triage instructions were initially included. We then excluded patients that were determined not to be trauma patients and those for whom the initial LERN call was from a hospital. Patients who followed the LERN trauma triage criteria were defined as the compliant group. Patients initially brought to a hospital **inconsistent** with the LERN trauma triage protocol defined as the noncompliant group (whether due to EMS discretion or patient request). We performed a Chi-Square analysis to compare differences between these two groups. Both identification of the outcome measures and establishment of a p-value of < 0.05 as statistically significant were determined before the beginning of the study.

Results: During 2014, pre-hospital/hospital providers called LERN for direction in the care of 14, 935 patients. We excluded 692 patients from our study because they were not trauma patients and 172 patients because their initial call came from a hospital. Our study, therefore, consists of 14,071 patients who were identified by the LERN call center as trauma patients and were triaged to a specific hospital. Of these patients, 13, 037 (92.7%) patients were compliant with the LERN protocol and 1,034 (7.3%) patients were noncompliant. The mechanism of injury and demographic parameters were not significantly different between the two groups. There were significantly fewer patients in the compliant group 570 **(4.3%)** who required transfer from their initial hospital to a second hospital than there were in the noncompliant group 312 **(30.2%)**, p<0.01. The mortality rate was significantly lower in the compliant group 81 **(0.6%)** than in the noncompliant group 21 **(2.03%)**, p<0.01.

Conclusion: Following a recognized trauma triage criteria resulted in a decreased need for secondary transfers. More importantly getting the patient to the correct hospital in a timely fashion resulted in a fivefold decrease in mortality. These data emphasize the value of an organized statewide trauma network that routes patients to the appropriate facilities. These data also support the American College of Surgeons perspective that minimizing secondary trauma transfers improves trauma patient outcomes.

ACS LEVEL I TRAUMA CENTERS OUTCOMES DO NOT CORRELATE WITH PATIENT PERCEPTIONS OF HOSPITAL EXPERIENCE

Bellal Joseph* MD, Asad Azim MD, Ansab Haider MD, Narong Kulvatunyou* MD, Terence O'Keeffe* MD, Lynn Gries MD, Gary Vercruysse* MD, Andrew Tang MD, Peter Rhee* MD, MPH, University of Arizona – Tucson

Invited Discussant: Frederick Rogers, MD

Introduction: HCAHPS is a data collection methodology for measuring patient's perception of their hospital experience and has been selected by Centers of Medicare and Medicaid Services (CMS) as the validated and transparent national survey tool with publicly available results. Beginning in 2012 hospital reimbursements rates are linked to HCAHPS data, which is based on patient satisfaction scores. The aim of this study was to assess whether HCAHPS scores of Level-1 trauma centers correlate with actual hospital performance.

Methods: We performed retrospective analysis of latest publicly available HCAHPS data (2014 – 2015). All ACS verified Level-I trauma centers for each state were identified from ACS registry and following data points were collected for each hospital. HCAHPS linear mean scores regarding cleanliness of the hospital, doctor and nurse communication with the patient, staff responsiveness, pain management, overall hospital rating and patient willingness to recommend the hospital. Primary outcome measure was serious complication score. Secondary outcome measures were failure-to-rescue scores and readmission after discharge scores. Spearman correlation analysis was performed.

Results: A total of one hundred and twenty ACS verified Level-I trauma centers across 46 states were included. Median [IQR] overall hospital rating score for Level-I trauma centers was 89 [87-90]. Mean ± SD score for serious complication was 0.96±0.266, failure-to-rescue was 123.06±22.5, and readmission after discharge was 15.71±1.07. On performing spearman correlation overall HCAHP based hospital rating scores did not correlate with serious complications (correlation coefficient = 0.171 p= 0.064), readmission after discharge (correlation coefficient = - 1.79 p= 0.052) and failure-to-rescue (correlation coefficient = -0.188 p= 0.043).

Conclusion: Our findings suggest that no correlation exists between HCAHPS patient satisfaction score and hospital performance for level I trauma centers. CMS should reconsider hospital reimbursement decisions based on HCAHP patient satisfaction scores
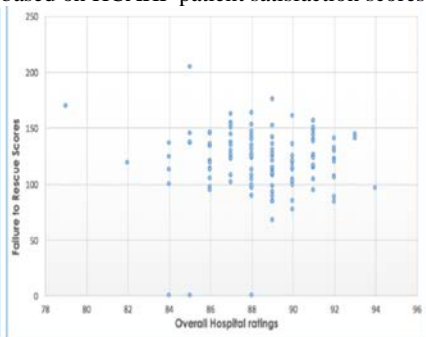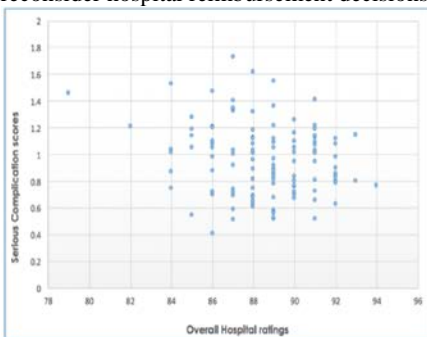
ATTEMPTING TO VALIDATE THE OVER/UNDER TRIAGE MATRIX AT A LEVEL I TRAUMA CENTER

James W. Davis* MD, Rachel Dirks Ph.D., Lawrence P. Sue MD, UCSF Fresno

Invited Discussant: Eileen Bulger, MD

Introduction: The Optimal Resources Document (ORD) mandates criteria for trauma activation that are based on mechanism and physiologic and anatomic criteria. The ORD then requires the retrospectively calculated Injury Severity Score (ISS) to evaluate the appropriateness of tiered trauma activation using the over/under triage matrix (Matrix).The COT recommends a goal of < 50% over triage and < 5% under triage. We hypothesized that the ISS-driven Matrix does not reflect outcomes and risk of delayed treatment with under triage. The purpose of this study was to assess the utility of the Matrix by comparing results of tiered activation with those 'appropriately triaged' and 'under triaged' by Matrix.

Methods: Trauma registry data were reviewed from 1/2013- 12/2015 at an ACS verified Level I trauma center with ACS tiered activation criteria. Patients with an ISS ≥ 16 were classified by activation level (full, limited, consultation), and triage category calculated by Matrix. Under triage rate by Matrix methodology is patients with an ISS ≥ 16 without full activation/all patients without full activation. Patients were compared by demographics, injuries, initial vital signs, procedures, delays to procedure, ICU admission, hospital lengths of stay (LOS), and mortality. Data are presented as mean ± SD or median [IQR]. Statistical analysis was performed using Chi square and Mann Whitney U tests with significance attributed to a p value < 0.05.

Results: 7031 patients had trauma team activation. Overall compliance with the ACS tiered activation criteria was 99%. By Matrix, the under triage rate was 24%. Of 2282 patients with an ISS ≥ 16, 1,025 were appropriately triaged (full activation), and 1257 were under triaged (379 limited activation and 878 consultation).

Matrix	Appropriate triage	Under triaged	Under triaged
ACS criteria	Full activation	Limited activation	Consultation
N	1025	379	878
Age	39 ± 20	43 ± 22*	51 ± 23*
GCS	6 [3-15]	15 [13-15]*	15 [14-15]*
ISS	26 [21-33]	22 [17-27]*	19 [17-24]*
Heart rate	98 [78-120]	91 [78-108]*	86 [74-99]*
SBP	105 [80-130]	124 [111-140]*	132 [120-148]*
Base Deficit	-5 [-8 - -2]	-3 [-5 - -1]*	-2 [-4 - -1]*
Exlap/Crani	367 (36%)	93 (25%)*	126 (14%)*
Delay to Exlap/Crani	29 (3%)	1 (0%)*	9 (1%)*
ICU admission	735 (72%)	195 (51%)*	271 (31%)*
Hospital LOS	14 ± 15	12 ± 13	7 ± 8*
Mortality	332 (32%)	27 (7%)*	30 (4%)*

*p < 0.005 compared to appropriate triage

Conclusion: Tiered response criteria for trauma team activation appropriately identified patient acuity and outcomes without causing treatment delays in limited activations and consultations. The Matrix had poor agreement with ACS-COT trauma team activation criteria. Compliance with the ACS-COT activation criteria should be used to evaluate under triage rather than the ISS-driven Matrix.

SUICIDE SECONDARY TO FIREARMS: WEAKER GUN STATE LAWS ARE ASSOCIATED WITH INCREASED RATES OF DEATH

Rodrigo F. Alban* MD, FACS, Galinos Barmparas MD, Ara Ko MD,MPH, Cedars-Sinai Medical Center

Invited Discussant: Ronald Gross, MD

Introduction: Firearm related violence remains a significant cause of death and injury in the U.S. According to the CDC nearly two thirds of gun deaths are suicides, and they outnumber firearm homicides nearly two to one. In addition, suicide is the 10th leading cause of death in the U.S. among adolescents and young adults aged 10-24 years. With significant controversy, several states have mandated different laws to restrict gun ownership. In order to determine a more objective method to understand suicide estimates and outcomes at a national level we sought to examine the relationship in firearm related injuries amongst states based on their firearm law patterns.

Methods: We reviewed the National Inpatient Sample (NIS) database from 2010-2011 for all firearm related injury codes (ECODES) with the exception of law-enforcement related firearm injuries. ECODES included suicide, assault, accidental and undetermined. State related firearm laws were scored using the Brady scoring system from A (stricter laws) to F (weaker laws). Patient demographic information, location (by state), and mortality were analyzed in these 5 groups (A, B, C, D and F). The U.S. Census Bureau was used to calculate weighted estimates of injury per 100,000 population for the year 2010 and 2011 based on the abstracted NIS ECODES.

Results: A total of 60,945 weighted counts were identified nationwide during the study period. Overall suicide rates were significantly higher in states with weaker gun laws (grade F) when compared with states with stricter gun laws (grade A): 2.59/100,000 vs. 0.82/100,000 (p<0.001). Suicide-related mortality was nearly 3-fold higher in grade F (0.98/100,000) vs. grade A (0.34/100,000) states, p<0.001. In addition, states with grades C and D were also noted to have increased rates of suicide-related mortality when compared with grade A states (0.78/100,000 and 0.50/100,000 vs. 0.34/100,000, respectively, p<0.001). In patients younger than 25 years old, we noted a higher incidence of all firearm related injuries in grade A vs. grade F states (12.58/100,000 vs. 8.76/100,000, p<0.001). Despite this higher overall incidence, suicide-related mortality secondary to firearm injuries was significantly lower in grade-A states compared to grade-F states (0.14/100,000 vs. 0.54/100,000, p<0.001).

Conclusion: Firearm related suicide injuries are more common in states with weaker gun laws; most importantly suicide deaths due to firearms were significantly higher in these states. Efforts aimed at nationwide standardization of firearm state laws are warranted, particularly for young adults and suicide-prone populations.

UTILITY OF THE INJURED TRAUMA SURVIVOR SCREEN TO PREDICT PTSD AND DEPRESSION IN HOSPITALIZED TRAUMA PATIENTS

Terri A. DeRoon-Cassini Ph.D., Josh Hunt Ph.D., Ann Marie Warren Ph.D., Karen Brasel* MD, MPH, Medical College of Wisconsin

Invited Discussant: Ronald Stewart, MD

Background: The American College of Surgeons Committee on Trauma has recommended PTSD and Depression screening for admitted trauma survivors, yet a brief screening tool validated on hospitalized trauma patients to predict PTSD and Depression does not exist. The purpose of this study was to evaluate the utility of a brief new screening tool for PTSD and Depression.

Methods: 276 trauma patients admitted to two Level I trauma centers completed the newly created 9-item Injured Trauma Survivor Screen for PTSD and depression (5 items for PTSD, 5 items for Depression, with 1 overlapping item), as well as injury and demographic information. At 1 (n=137) and 6 (n=99) months posttrauma the gold standard for assessing PTSD (CAPS) and the Center for Epidemiologic Studies Depression – Revised measure (CESD-R) of depression were administered. ROC curve analysis and sensitivity and specificity were utilized.

Results: The rate of depression was 20% (n = 28) and the rate of PTSD was 28.7% (n = 40). Of those who met PTSD criteria at one month (n = 40) based on their CAPS-5 score, 55% (n = 22) met criteria for comorbid depression based on their score responses to the CESD-R ($\chi2(1) = 42.418$, $p < 0.001$, $\varphi = 0.552$). The new 9 item Injured Trauma Survivor Screen (ITSS) for PTSD and Depression administered in the hospital within 4 days of injury demonstrated a 75% sensitivity for identifying risk for PTSD and Depression, 94% specificity for PTSD and 96% specificity for depression, with a cut-off score of 2 out of 5 based on a ROC curve analysis.

Conclusions: The newly created 9 item Injured Trauma Survivor Screen demonstrated strong sensitivity and specificity for predicting PTSD and Depression when administered during hospitalization following injury. The ITSS takes less than 5 minutes to administer and is a reliable solution validated on a population it is intended to be used. Trauma centers should consider adopting this screening tool to meet the ACS-CoT recommendations.

EXOSOMES, NOT PROTEIN OR LIPIDS, IN MESENTERIC LYMPH ACTIVATE INFLAMMATION: UNLOCKING THE MYSTERY OF POST-SHOCK MULTIPLE ORGAN FAILURE

Mitsuaki Kojima MD, Joao A. Gimenes-Junior Ph.D., Todd W. Costantini* MD, Simone Langness MD, Ophelie Z. Lavoie Gagne BS, Koji Morishita MD, Brian P. Eliceiri Ph.D., Andrew Baird Ph.D., Raul Coimbra* MD, Ph.D., University of California, San Diego

Invited Discussant: David Livingston, MD

Introduction: Post-shock organ failure is the leading cause of late mortality in trauma patients. Studies have shown that mesenteric lymph (ML) plays a crucial role in driving the systemic inflammatory response after trauma/hemorrhagic shock (T/HS). The specific mediators in the ML that contribute to its biological activity remain unclear despite decades of study. Exosomes are extracellular microvesicles that are shed into body fluids such as serum and urine, play an important role in intercellular communication, and have immunomodulatory effects. We hypothesized that exosomes are present in the ML after trauma/shock and are responsible for the biological activity of ML.
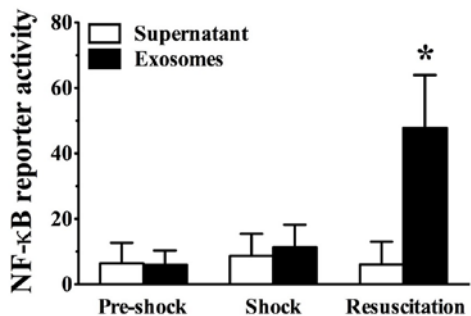
Methods: Male rats underwent cannulation of the femoral vessels and mesenteric lymph duct prior to T/HS (mean arterial pressure 35 mmHg for 60 min), followed by resuscitation with shed blood and 2 times normal saline. The ML was collected during 3 distinct time periods (pre-shock, shock and resuscitation phase) and subsequently separated into exosome and supernatant fractions by differential centrifugation. Exosomes were visualized and quantified using nanoparticle tracking analysis and by immunoblotting for exosome markers CD63 and HSP70. The biological activity of ML exosomes and supernatant were characterized using a monocyte NF-κB reporter assay and by measuring macrophage intracellular TNF-α production using flow cytometry.

Results: Exosomes were identified in ML by size (96.3 ± 40.1 nm) and expression of the exosome markers CD63 and HSP70. The number of exosomes present in the ML was increased during shock (1.5×10^{11}, $p<0.05$) compared to pre-shock (6.5×10^{10}) and resuscitation (6.6×10^{10}) phases.

However, biological activity of exosomes isolated during the resuscitation phase was markedly increased and caused an 8-fold increase in monocyte NF-κB activation compared to supernatant ($p<0.001$, see figure). Macrophage TNF-α production was also increased after exposure to exosomes harvested in the resuscitation phase ($p<0.05$). The ML supernatant fraction had no effect on macrophage TNF-α production during any phase.

Data shown as mean ± SD (n = 4)
*$p <0.001$ versus all other groups

Conclusion: Exosomes are released into the ML after injury and demonstrate increased biological activity during resuscitation. Our findings show that exosomes, and not the liquid fraction of ML, are the major biological active component triggering the systemic inflammatory response after T/HS.

A STUDY OF METABOLIC DYNAMICS IN CRITICALLY INJURED PATIENTS

Kai WANG DO, MD, Mingwei SUN MD, Charles D. Lu, Ph.D., Jun ZENG, MD,
Sichuan Academy Of Medical Sciences.

Invited Discussant: David Harrington, MD

Introduction: By combining the techniques of metabolomics and computational biology, this research aims to explore the mechanism of metabolic dynamics in critically injured patients and develop a new method for early warning for mortality.

Methods: A prospective cohort study was conducted, a group of critically injured patients were included, and their serum samples were collected for 1H-NMR metabolomics (DRX 600MHz NMR ,Bruker Biospin Rheinstetten, Germany) analysis. The data was processed with partial least squares regression and support vector machine, to explore the role of enzyme-gene network regulatory mechanism in critically injured metabolic network regulation and to build a quantitative prediction model for early warning of fast death. The survival percentage was estimated using Kaplan-Meier curves.

Results: In total, 60 patients were enrolled between January 2013 and December 2014 and were divided into three groups: 19 patients with severe traumatic brain injury, 26 patients with thoracic or abdominal surgery and 15 patients with severe burns. Age, body mass index (BMI) and APACHE II scores were not significantly different between groups. The survival percentage of patients with severe burns is significantly different from the other two groups ($P<0.01$). There were significant differences in plasma metabolome between the surviving patients and deceased ones (Figure 1). Compared to the surviving patients, disturbances of neopterin, corticosterone, 3-methylhistidine, homocysteine, Serine, tyrosine, prostaglandin E2, tryptophan, testosterone and estriol, were observed in the plasmas of deceased ones. Six metabolic markers (neopterin, 3-methylhistidine, prostaglandin E2, homocysteine, testosterone and estriol) were significantly different. GO analysis showed that 66 enzymes and genes regulated the 6 key metabolic markers. Among patients of different injury stages, there were significant differences in plasma metabolome (Figure 2). From T0 to T50 stages of injury, increased levels of neopterin, corticosterone, prostaglandin E2 and estriol, together with decreased levels of homocysteine, tryptophan and testosterone, were observed. Eventually, the quantitative prediction model of death warning was established. Cross-validation results showed that the predicted effect was good (RMSE=0.18408, R2=0.87 P=0.036).

Conclusion: Systems biology approaches based on metabolomics and enzyme-gene regulatory network analysis can be used to quantify the metabolic dynamics of patients with critically injuries and to predict death of critically injured patients by plasma 1H-NMR metabolomics.
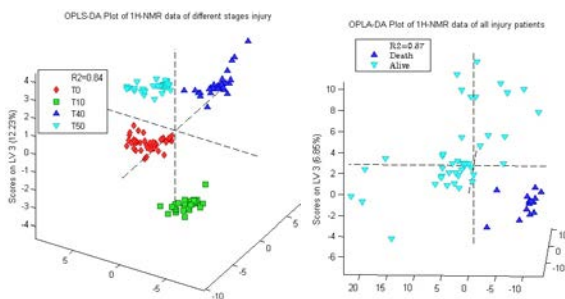
PREPERITONEAL PELVIC PACKING REDUCES MORTALITY IN PATIENTS WITH LIFE-THREATENING HEMORRHAGE DUE TO UNSTABLE PELVIC FRACTURES

Clay Cothren Burlew* MD, Andrea E. Geddes BA, Ernest E. Moore* MD, Amy E. Wagenaar MD, Jeffrey L. Johnson* MD, Fredric M. Pieracci MD, Charles Fox* MD, Eric M. Campion MD, Philip F. Stahel* MD, Denver Health Medical Center

Invited Discussant: David Spain, MD

Introduction: A 2015 AAST multicenter trial reported a 32% mortality rate for complex pelvic fracture patients who present in shock. Angioembolization is the most common intervention for hemorrhage control; in 2015 the Maryland Shock Trauma group revealed time to angioembolization averaged over 5 hours. The goal of this study was to evaluate the time to intervention and outcomes of an operative approach to hemorrhage from pelvic fractures. We hypothesized direct preperitoneal pelvic packing (PPP) results in a shorter time to intervention and lower mortality.

Methods: In 2004 we initiated a protocol in pelvic fracture patients employing PPP as the initial management for pelvic bleeding with hemodynamic instability despite 2 units of blood transfusion. Patients with prehospital arrest/emergency department thoracotomy who subsequently underwent PPP were excluded.

Results: During the 11 year study period, 2293 patients were admitted with pelvic fractures; 128 (6%) consecutive patients underwent PPP (mean age 43 ± 2 years and ISS 48 ± 1.2). The lowest mean emergency department SBP was 74 ± 2 mmHg and highest heart rate was 120 ± 2. Median time to operation was 44 minutes. An additional 3 ± 0.2 operative procedures were performed in 109 (85%) patients aside from external fixation and PPP. Median red cell transfusions prior to PPP completion compared to the subsequent 24 postoperative hours were 8 units versus 3 units (p<0.05). After PPP, 16 (13%) patients underwent angioembolization (AE) with a documented arterial blush. One patient had perineal necrosis from empiric bilateral internal iliac artery embolization. Mortality in this high-risk group was 21%. Death was due to traumatic brain injury (9), multiple organ failure (4), withdrawal of support (4), pulmonary failure (3), cardiac failure (3), adverse physiology (3), and invasive Mucor infection (1). Of those patients with adverse physiology, 2 died in the operating room at 89 minutes and 100 minutes after hospital arrival while 1 died in the ICU 9 hours after arrival.

Conclusion: PPP results in a shorter time to intervention and lower mortality compared to modern series utilizing AE. Examining mortality, only 3 (2%) deaths were attributed to the immediate sequelae of bleeding with physiologic failure. With time to death under 100 minutes in 2 of those patients, AE is unlikely to have been feasible. Furthermore, arterial bleeding was present in the minority of patients, rendering angiography of limited utility. PPP should be utilized for pelvic fracture related bleeding in the patient who remains hemodynamically unstable despite initial blood transfusion.

PELVIC FRACTURE PATTERN PREDICTS THE NEED FOR HEMORRHAGE CONTROL INTERVENTION - RESULTS OF A MULTI-INSTITUTIONAL STUDY

Todd W. Costantini* MD, Raul Coimbra* MD, Ph.D., John Holcomb* MD, Richard Catalano MD, Thomas M. Scalea* MD, Lashonda Williams MD, Scott Keeney DO, Jason Sperry* MD, MPH, Dimitra Skiada MD, Brian H. Williams MD, Robert C. Mackersie* MD, Forrest Moore* MD, Pelvic Fracture Study Group AAST Multi-Institutional Trials Committee

Invited Discussant: Joseph Galante, MD

Introduction: Early identification of patients with pelvic fractures at risk for severe bleeding requiring intervention is critical. We performed a multi-institutional study to test our hypothesis that pelvic fracture patterns predict the need for a pelvic hemorrhage control intervention.

Methods: This prospective, observational multi-center study enrolled patients with pelvic fracture due to blunt trauma. Inclusion criteria included shock on admission (SBP<90 or HR>120 and base deficit < -5), and the ability to review pelvic imaging. Demographic data, open pelvic fracture, blood transfusion, pelvic hemorrhage control intervention (angioembolization, external fixator, pelvic packing and/or REBOA), and mortality were recorded. Pelvic fracture pattern was classified according to Young-Burgess by either a trauma surgeon or radiologist in a blinded fashion. Predictors of the need for blood transfusion, pelvic hemorrhage control intervention, and mortality were analyzed by univariate and multivariate logistic regression analysis.

Results: A total of 163 patients presenting in shock were enrolled from eleven Level-1 trauma centers. The majority were males (57.7%) with a mean age of 44.1 ± 20.2 and ISS of 28.0 ± 14.2. The most common pelvic fracture pattern (see Table) was Lateral Compression (LC) I, followed by LC II, and Vertical Shear. Of the 12 patients with an Anterior-Posterior Compression (APC) III fracture, 10 (83%) required a pelvic hemorrhage control intervention. APC III (OR 109.4, CI 12.0-994.2) and Vertical Shear (OR 7.0, CI 2.0-24.3) patterns predicted the need for pelvic hemorrhage control intervention on multivariate analysis.

Pelvic Fracture Pattern for Patients in Shock (n=163 patients)	
Lateral Compression I	58 (35.6%)
Lateral Compression II	37 (22.7%)
Vertical Shear	22 (13.5%)
Lateral Compression III	18 (11.0%)
Anterior-Posterior Compression III	12 (7.4%)
Anterior-Posterior Compression II	11 (6.7%)
Anterior-Posterior Compression I	5 (3.0%)

Open pelvic fracture (n=12) was also associated with the need for hemorrhage control intervention (OR 7.4, CI 1.5-36.2). While LC I fractures were most common, this fracture pattern was least likely to be associated with the need for pelvic hemorrhage control intervention (23%, p<0.05) on univariate analysis, and a decreased need for blood transfusion on multivariate analysis (OR 0.2, CI 0.05-0.9). Overall in-hospital mortality for patients admitted in shock with pelvic fracture was 30% and did not differ based on pelvic fracture pattern on multivariate analysis.

Conclusion: Blunt trauma patients admitted in shock with APC III or Vertical Shear fracture patterns, or patients with open pelvic fracture are at greatest risk of severe bleeding requiring pelvic hemorrhage control intervention.

FAILURE OF NONOPERATIVE MANAGEMENT OF PEDIATRIC BLUNT LIVER AND SPLEEN INJURIES: A MULTICENTER PROSPECTIVE STUDY

Maria E. Linnaus MD, Crystal S. Langlais MPH, Nilda M. Garcia* MD, Adam C. Alder MD, James W. Eubanks III, MD, R. Todd Maxson* MD, Robert W. Letton* MD, Todd A. Ponsky MD, Shawn D. St. Peter MD, Amina Bhatia MD, MS, Daniel J. Ostlie MD, David W. Tuggle* MD, Karla A. Lawson Ph.D., Alexander R. Raines MD, David M. Notrica* MD, Phoenix Childrens Hospital

Invited Discussant: Barbara Gaines, MD

Introduction: Nonoperative management (NOM) is standard of care for blunt liver and spleen injuries (BLSI); only 5% of patients fail NOM in retrospective reports. No prospective studies examine failure of NOM of BLSI in children. The aim of this study was to determine the frequency and clinical characteristics of failure of NOM in pediatric BLSI patients.

Methods: A prospective observational study was conducted on patients 0 to 17 years presenting to any of ten level 1 pediatric trauma centers April 2013 and January 2016 with BLSI on computed tomography. Management of BLSI was based on an evidence-based pediatric guideline. Failure of NOM was defined as needing laparoscopy or laparotomy for BLSI. Descriptive statistics were reported. Children failing NOM were compared to those with successful NOM using Mann-Whitney, Chi-Square, or Fisher's exact as appropriate.

Results: A total of 974 patients met inclusion; 483 (50%) had liver injury, 399 (41%) spleen, and 92 (9%) had both. Most patients were male (n=610; 63%) with a median age of 10.3 years (IQR: 5.9, 14.2). A total of 58 (6%) underwent laparotomy or laparoscopy, but only 28 (3%) underwent surgery for spleen or liver bleeding. Other operations included 24 intestinal surgeries, 7 drain placements, and 3 pancreatectomies. No grade 1 or 2 splenic injuries failed NOM. For grade 3 injuries, 2% of liver and 3% of spleen injuries failed. Of 16 patients who underwent angioembolization, only 2 failed NOM. Patients who failed NOM for BLSI were more likely to have tachycardia (p<0.001) and hypotension (p<0.001) in the trauma bay, a lower initial hemoglobin (10.5 vs 12.4; p<0.001), a higher median injury grade (5 vs. 3; p<0.001) and were more likely to have both a liver and spleen injury vs. isolated liver (p<0.001) or isolated spleen (p<0.001). Patients who failed were more likely to receive blood (23/28 vs 155/945; p<0.001) and median time from injury to first blood transfusion was 2 hours for those who failed *vs*. 6 hours for those who did not (p=0.002). Overall mortality rate was 21% in those who failed NOM due to bleeding.

Conclusion: NOM fails in 6% of children with BLSI, but only 3% of patients failed due to liver or spleen injury. For children failing NOM due to their BLSI, the mortality was 21%. No children with grade 1 or 2 splenic injuries failed NOM due to bleeding.

OVERALL SPLENECTOMY RATES REMAIN THE SAME DESPITE INCREASING USAGE OF ANGIOGRAPHY IN THE MANAGEMENT OF HIGH GRADE BLUNT SPLENIC INJURY

Scott Dolejs MD, Ben L. Zarzaur* MD, MPH, Indiana University School of Medicine

Invited Discussant: Andrew Peitzman, MD

Introduction: Current algorithms for the management of blunt splenic injury (BSI) have shifted to a greater reliance on angiography (ANGIO) in an effort to increase splenic salvage in adults. Several studies indicate an association between increased use of ANGIO and decreased rates of failure of non-operative management (NOM), or delayed splenectomy. However, delayed splenectomy rates are dependent on the types of patients selected for early splenectomy. Associations between ANGIO utilization and improved delayed splenectomy rates could be spurious. Longitudinal comparisons of total splenectomy rates, including both early and delayed splenectomy, could help address this issue. If ANGIO utilization indeed results in saving more spleens, then there should be a reduction in the overall splenectomy rate as ANGIO utilization increases. The purpose of this study was to understand the rate of splenectomy over time and to determine if ANGIO may be impacting the overall splenectomy rate.

Methods: The National Trauma Data Bank was used to identify patients 18 years and older with high grade BSI (Abbreviated Injury Scale ≥3) treated at Level I or II trauma centers between 2008-14, that admitted at least 30 patients with high-grade BSI. Patients who were transferred or died in the emergency department (ED) were excluded. Splenectomy was defined as early if performed within 6 hours of ED admission and delayed if greater than 6 hours. Trends were studied over time. Univariate and multivariable analyses were performed and the Bonferonni correction was used to account for multiple comparisons.

Results: There were 52,705 patients included for analysis. Compared to earlier time frames, there were more early splenectomies and less late splenectomies performed in the most recent period (p-value=0.0001 and 0.0001 respectively). However, the use of ANGIO has rapidly increased from 5.1% in 2008-2009 to 12.2% in 2012-2014 (p-value=0.0001). The overall rate of splenectomy was stable (p-value=0.3416) (FIGURE).

Early Splenectomy   Late Splenectomy   —Angiography

Conclusion: Over the last 7 years, the rate of angiography has been steadily rising while the overall rate of splenectomy has been stable. Incidence of early splenectomy has increased over time with a corresponding decreased rate of late splenectomy. This may indicate that clinicians have become better at identifying patients requiring splenectomy earlier in their injury course. The lack of improved overall splenic salvage, despite increased ANGIO, calls into question the role of ANGIO for high-grade splenic salvage on a national level.
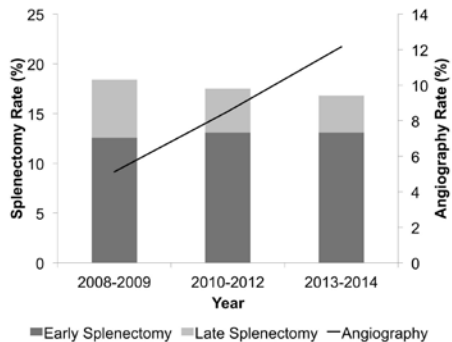
THERE IS NOTHING LITTLE ABOUT THE IMPACT OF BABY ASPIRIN: THE RESULTS OF A PROSPECTIVE AAST MULTI-INSTITUTIONAL TRIAL OF ORAL ANTICOAGULANTS

Leslie M. Kobayashi* MD, Marko Bukur* MD, Richard D. Catalano MD, Eric Ley* MD, Tammy Kopelman* MD, Jacob Quick MD, Omar Rivera MD, Patrick Bosarge* MD, Carlos V. Brown* MD, John Berne* MD, Stephen Kaminski* MD, Raminder Nirula* MD, Martin Schreiber* MD, Forrest D. Moore* MD, Raul Coimbra* MD, AAST Multi-Institutional Trials Committee

Invited Discussant: Charles Wade, PhD

Introduction: The number of anticoagulated trauma patients is increasing. Trauma patients on warfarin have been found to have poor outcomes, particularly following intracranial hemorrhage (ICH). However, the effect of novel oral anticoagulants (NOAs) such as dabigatran, rivaroxaban, and apixaban on trauma outcomes is unknown. We hypothesized that patients on NOAs would have higher rates of ICH, ICH progression, and death compared to patients on traditional anticoagulant and antiplatelet agents.

Methods: This was a prospective observational trial across 16 trauma centers. Inclusion criteria consisted of any trauma patient admitted on aspirin, clopidogrel, warfarin, dabigatran, rivaroxaban, or apixaban. Demographic data, admission vital signs, mechanism of injury, injury severity scores, laboratory values, and interventions were collected. Outcomes included ICH, progression of ICH, and death. Univariate, bivariate and logistic regression analyses were performed.

Results: A total of 1844 patients were enrolled. Mean age was 74.9 years (SD ± 13.8), 46% were female, 77% were Caucasian. At least one co-morbidity was reported in 94% of patients. Blunt trauma accounted for 99% of patients and the median ISS was 9 (IQR 4-14). 50% of patients were on antiplatelet agents, 33% on warfarin, 10% on NOAs, and 7% on combination therapy or subcutaneous agents.

ICH occurred in 30% of patients, of which 40% had a Head AIS ≥3. Compared to all other agents, patients on aspirin (90% 81mg, 10% 325mg) had the highest rate of ICH (35%), this correlated with the highest risk of ICH on multivariate analysis (OR 1.7, CI 1.3-2.2, p<0.001). Patients taking NOAs were significantly less likely to have ICH (OR 0.68, CI 0.46-0.99, p=0.049) when compared to all other agents on multivariate analysis. Progression of injury occurred in 17% of patients with ICH. On multivariate analysis risk of progression between agents was similar. When warfarin patients were subdivided by INR, therapeutic patients (INR 1.4-4), were at significantly increased risk of ICH progression (OR 4.7 CI 1.6-13.9, p=0.005) compared to those who were subtherapeutic (INR ≤1.4).

Overall study mortality was 7% and was not significantly different between groups on univariate analysis. NOAs as a group were not associated with increased risk of death on multivariate analysis.

Conclusion: Contrary to our hypothesis, patients on aspirin had the highest rate and risk of ICH. Patients on NOAs were not at higher risk for ICH, progression, or death.

Cold storage of platelet concentrates supplemented with resveratrol/cytochrome c preserves platelet function

Susan Evans* MD, Michael Ekaney Ph.D., William Powers MD, Iain McKillop Ph.D., Carolinas Medical Center

Invited Discussant: Martin Schreiber, MD

Introduction: The decline of platelet function during storage is attributed to decreased mitochondrial function and/or bacterial contamination. We hypothesized mitochondrial support agents, resveratrol (Res; antioxidant) and cytochrome c (Cyt c; substrate), in combination with hypothermic storage would extend the viability of stored platelets.

Methods: Whole blood derived platelets from 20 donors were pooled into four independent sets in 100% plasma and stored in standard platelet pooling bags for 1-10 days with mild agitation (70rpm). Res (50μM) or Cyt c (100μM) was added immediately prior to storage (22°C or 4°C). Platelet count, platelet coagulation function (thromboelastography), soluble platelet activation markers (CD62P/sP-Selectin), oxygen consumption, catalase activity, lipid peroxidation, glucose, lactate, and pH were assayed in triplicate up to 10 days post-storage.

Results: Independent of storage temperature, platelet function significantly deteriorated with time indicated by increased %ADP (Adenosine diphosphate) and %AA (Arachidonic acid) inhibition, decreased %ADP and %AA aggregation. In the 4°C storage group, treatment with Res or Cyt c markedly decreased %ADP and %AA inhibition up to 10 days post-treatment, an effect not observed at 22°C. In addition, Cyt c increased oxygen consumption at 22°C but neither Cyt c or Res had an effect at 4°C. Analysis of endogenous antioxidant activity demonstrated steady state catalase activity during storage and this activity was further reduced by pretreatment with Res or Cyt c (up to 10 days post-treatment) independent of temperature. Conversely, total platelet count and CD62P was unchanged during storage and was not affected by Res and Cyt c while lipid peroxidation was reduced by Cyt c at 22°C. Glucose concentration decreased during storage, while lactate concentration increased with a decrease in pH. No significant effect on %ADP/AA inhibition/aggregation was observed when platelet concentrates were supplemented with glucose at day 5 of storage. However, an increase in oxygen consumption was observed.

Conclusion: Platelet function is preserved at 4°C versus 22°C for up to 10 days of storage. Treatment with Res or Cyt c modulates platelet function with administration of Res or Cyt c at the beginning of 4°C storage acting to preserve platelet function and mitochondrial activity, thus potentially extending platelet shelf life. Maintenance of physiological levels of glucose, lactate and pH may preservation platelet function for a longer duration at 4°C.

DAILY PROPRANOLOL ADMINISTRATION PREVENTS PERSISTENT INJURY-ASSOCIATED ANEMIA FOLLOWING SEVERE TRAUMA AND CHRONIC STRESS

Ines G. Alamo MD, MPH, Kolenkode B. Kannan Ph.D., Harry Ramos BS, Philip A. Efron MD, FACS, FCCM, Alicia M. Mohr* MD, FACS, FCCM University of Florida – Gainesville

Invited Discussant: Saman Arbabi, MD, MPH

Introduction: Following severe trauma, patients develop a norepinephrine mediated persistent injury-associated anemia that can last for weeks. This results in suppression of bone marrow (BM) erythroid colony growth and ineffective erythropoiesis. In persistent anemia, elevated erythropoietin (EPO) levels are insufficient, regardless, of suppressed hepcidin levels. Using a clinically relevant rodent model of lung contusion (LC), hemorrhagic shock (HS), and chronic stress (CS), we hypothesize that daily propranolol (BB), a non-selective beta-blocker, restores BM function.

Methods: Male Sprague-Dawley rats (n=4-6/group) were subjected to LCHS and LCHS/CS ± BB (10mg/kg). Hemoglobin (Hgb), plasma EPO, hepcidin, BM cellularity and CFU-GEMM, BFU-E and CFU-E colony growth were assessed. Data was presented as mean±SD; *p<0.05 vs. untreated counterpart by t-test.

Results: The addition of CS to LCHS leads to persistent anemia on day 7 and the use of BB improved Hgb levels (13.9±0.4* vs. 10.6±0.8 g/dL). Daily BB use following LCHS/CS improved BM cellularity, CFU-GEMM, BFU-E, and CFU-E colony growth (Table). LCHS/CS+BB significantly reduced plasma EPO levels and increased plasma hepcidin levels on day 7 (Table).

	Naïve	Seven Days Following LCHS/CS			
		LCHS	LCHS+BB	LCHS/CS	LCHS/CS+BB
BM cellularity (x10^6)	225±7	191±17	218±26*	164±12	221±31*
CFU-GEMM (colonies/plate)	36±1.3	29±2	35±2*	25±2	30±9*
BFU-E (colonies/plate)	59±0.8	43±4	55±4*	36±3	57±6*
CFU-E (colonies/plate)	64±2.4	49±7	60±2*	38±4	59±4*
Hgb (g/dL)	14.5±0.2	13.1±1.2	13.9±0.9	10.6±0.8	13.9±0.4*
Plasma EPO (pg/ml)	12±4	42±6	29±10*	49± 10	19±2*
Plasma hepcidin (pg/ml)	351±42	69±22	509±38*	56± 24	361±39*

Conclusion: Following severe trauma and chronic stress, daily propranolol use restored BM erythroid growth, plasma EPO and hepcidin levels, and resolved persistent injury-associated anemia. Daily propranolol preserved erythropoiesis by reducing the effects of hypercatecholaminemia on BM function after severe injury.
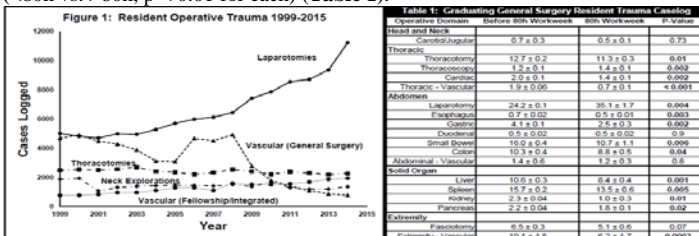
IS YOUR GRADUATING GENERAL SURGERY RESIDENT QUALIFIED TO TAKE TRAUMA CALL? A 15-YEAR APPRAISAL OF THE CHANGES IN GENERAL SURGERY EDUCATION FOR TRAUMA

Aaron M. Strumwasser MD, Daniel Grabo* MD, Kenji Inaba* MD, Damon Clark MD, Kazuhide Matsushima MD, Lydia Lam* MD, Elizabeth Benjamin* MD, Demetrios Demetriades* MD, LAC+USC Medical Center

Invited Discussant: Mark Malangoni, MD

Background: Trauma training in general surgery residency is undergoing an evolution. The 80-hour workweek, the growth of subspecialty care, interventional radiology and non-operative management has altered resident exposure to operative trauma. We hypothesize that current graduating general surgery residents are exposed to less operative trauma in the current training era. The specific aims of this study are: 1) to perform a comparative analysis of operative caseloads before-and-after the inception of the 80-hour workweek, 2) to note trends in specific operative domains and determine if deficiencies exist, 3) to determine whether subspecialty training (specifically vascular fellowship and integrated vascular surgery residency) has altered general surgery resident operative volume.

Methods: The Accreditation Council for General Medical Education databases on resident trauma operative volume were abstracted for trauma cases by category and by resident training year (junior vs. chief) for the years 1999-2015. Trauma cases were subdivided into the following domains: (1) head and neck, (2) thoracic, (3) abdomen, (4) solid organ and (5) extremity. Resident trauma experience (operative caseload, OC) was compared based on before the inception of the 80-hour (<80h) workweek (1999-2002) and after the 80-hour (>80h) workweek (2003-current). Differences in operative domains and procedures were then compared between groups. An F-test was used to test the groups for normality and an unpaired student's t-test was used to compare means among variables. Data is reported as mean ± standard error for each comparison. **Results:** A trend toward decreased operative trauma for general surgery residents was observed over time (mean OC (<80h vs. >80h) = 36,065.2 ± 1291.8 vs. 39,252 ± 1065.2 cases, p = 0.07) The number of trauma laparotomies increased (range = 4,708-11,234 cases) while there was a sharp decrease in vascular trauma (range = 4,926-799 cases), with neck explorations (range = 1,086-1,944 cases) and thoracotomies (range = 2,210-2,707 cases) relatively stable **(Figure 1)**. Moreover, as open vascular OC by general surgery trainees decreased (mean OC (<80h vs. >80h) = 4599.3 ± 135.3 vs. 2754.6 ± 443.0 cases, p < 0.01), there was a relative increase in the open vascular OC of vascular fellows and integrated vascular surgery residents (mean OC (<80h vs. >80h) = 844.8 ± 44.2 vs. 1464.5 ± 88.4 cases, p < 0.01). When individual graduating resident deficiencies were analyzed by time period (<80h vs. >80h), decreased operative volumes were prevalent across multiple domains including decreased operative caseloads in thoracic, abdominal, solid organ, and extremity vascular trauma (<80h vs. >80h, p < 0.01 for each) **(Table 1)**.

Figure 1: Resident Operative Trauma 1999-2015

Table 1: Graduating General Surgery Resident Traumalog

Operative Domain	Before 80h Workweek	80h Workweek	P-Value
Head and Neck			
Carotid/Jugular	0.7 ± 0.3	0.5 ± 0.1	0.73
Thoracic			
Thoracotomy	12.7 ± 0.2	11.3 ± 0.3	0.01
Thoracoscopy	1.2 ± 0.1	1.4 ± 0.1	0.002
Cardiac	2.0 ± 0.1	1.4 ± 0.1	0.002
Thoracic - Vascular	1.9 ± 0.06	0.7 ± 0.1	< 0.001
Abdomen			
Laparotomy	24.2 ± 0.1	35.1 ± 1.7	0.004
Esophagus	0.7 ± 0.02	0.5 ± 0.01	0.003
Gastric	4.1 ± 0.1	2.6 ± 0.3	0.002
Duodenal	0.5 ± 0.02	0.5 ± 0.02	0.9
Small Bowel	16.0 ± 0.4	10.7 ± 1.1	0.006
Colon	10.3 ± 0.4	8.8 ± 0.5	0.04
Abdominal - Vascular	1.4 ± 0.6	1.2 ± 0.3	0.8
Solid Organ			
Liver	10.6 ± 0.3	8.4 ± 0.4	0.001
Spleen	15.7 ± 0.3	13.5 ± 0.6	0.005
Kidney	2.3 ± 0.04	1.0 ± 0.3	0.01
Pancreas	2.2 ± 0.04	1.8 ± 0.1	0.02
Extremity			
Fasciotomy	6.5 ± 0.3	5.1 ± 0.6	0.07
Extremity - Vascular	19.1 ± 1.5	6.2 ± 1.7	0.0003

Conclusions: A significant paradigm shift for trauma training has occurred. Based on the data, an alarming rate of graduating general surgery residents are completing training with substantially less experience in defined trauma categories. A call for advanced simulation training in general surgery residency is needed to augment operative experience for trainees. Due to a decline in trauma operative volume for the average resident, advanced fellowship training should be encouraged specifically for those residents interested in a career in trauma and acute care surgery.

EXPANDING THE SCOPE OF QUALITY MEASUREMENT IN SURGERY TO INCLUDE NON-OPERATIVE CARE: RESULTS FROM THE ACS NSQIP EMERGENCY GENERAL SURGERY PILOT

Michael W. Wandling MD, Clifford Y. Ko MD, MS, MSHS, Paul E. Bankey, MD, PhD, Chris Cribari* MD, H. G. Cryer* III, MD, Ph.D., Jose J. Diaz, MD, Therese M. Duane, MD, MBA, S. M. Hameed MD,MPH, Matthew M. Hutter MD,MPH, Michael H. Metzler* III, MD, Justin L. Regner MD, Patrick M. Reilly* MD, H D. Reines MD, Jason L. Sperry* MD, MPH, Kristan L. Staudenmayer* MD, Garth H. Utter* MD, MSc, Marie L. Crandall* MD, MPH, Avery B. Nathens* MD, Ph.D., American College Of Surgeons

Invited Discussant: John Fildes, MD

Introduction: Patients managed non-operatively are typically excluded from risk-adjusted benchmarking programs, including ACS NSQIP. As such, optimal performance evaluation is not possible for specialties like emergency general surgery (EGS) where non-operative management is common. We developed a multi-institutional EGS clinical data registry within ACS NSQIP that includes patients managed non-operatively to understand variability in non-operative care across centers and gaps in performance evaluation that result when only operative cases are considered.

Methods: Using ACS NSQIP infrastructure and methodology, surgical consultations for small bowel obstruction (SBO), cholecystitis, and appendicitis were sampled at 13 hospitals. Standard NSQIP variables and 16 EGS-specific variables were abstracted with 30-day follow-up. To determine the influence of complications in non-operative patients, rates of serious morbidity, mortality, and readmission were identified and hospitals were ranked based on complication rates with and then without including non-operative cases.

Results: 2,076 patients were included, 29.3% with SBO, 24.2% with cholecystitis, and 46.5% with appendicitis. Overall, 27.6% of patients were managed non-operatively (SBO=69.8%, cholecystitis=16.7%, appendicitis=6.6%). Rates of non-operative management across hospitals ranged from 53.3%-77.5% for SBO, 0.0%-35.3% for cholecystitis, and 1.8%-10.0% for appendicitis. While patients treated non-operatively accounted for only 27.6% of included patients, they accounted for 41.6% of readmissions and 35.6% of all serious morbidities. Including non-operative cases in performance evaluation resulted in a change in performance rank for 9 hospitals, with 5 changing performance quartiles.

Conclusion: These data reveal marked variability in non-operative management rates across centers and significant 30-day complication rates for non-operative management in EGS. This study demonstrates the gap in performance evaluation that exists when non-operative patients are excluded from surgical quality assessment. Including these patients in clinical registries, pay-for-performance initiatives, and public reporting programs is important for performance evaluation and improving the care of all surgical patients, not just those who have an operation.

SARCOPENIA INCREASES LONG-TERM MORTALITY IN ELDERLY PATIENTS UNDERGOING EMERGENCY GENERAL SURGERY

Arturo J. Rios-Diaz MD, Jennifer W. Uyeda MD, Zara Cooper* MD, MSc, FACS, Ali Salim* MD, FACS, Aaron Sodickson MD,Ph.D., Erika L. Rangel MD, MS, FACS
Brigham and Womens Hospital

Invited Discussant: Kevin Schuster, MD, MPH

Background: Sarcopenia, or the loss of lean muscle mass, is a key component of frailty. Frailty is associated with poor postoperative outcomes, but the ability to quantify it is limited in the emergency setting. Sarcopenia is an objective measure that can be easily calculated from preoperative imaging. It has been associated with higher in-hospital mortality following emergency general surgery in elderly patients, but little is known about its effect on long-term outcomes in this group. We sought to determine the impact of sarcopenia on long-term mortality after emergency general surgery in elderly patients.

Methods: We identified patients >70 years who underwent emergent abdominal surgery from 2006-2011. Patients without preoperative computed tomography (CT) or recorded height were excluded. The average bilateral psoas muscle cross-sectional area (PSA) at the L3 level, normalized for height, was calculated using preoperative CT images. Sarcopenia was defined as normalized PSA in the lower sex-specific quartile. Primary outcome was mortality at 1 year. Mortality at 30 days (d), 90d, 180d were also examined. Cox proportional hazards regression was used to determine the independent association of sarcopenia with mortality at each time point. Models were controlled for age, gender, race, Charlson comorbidity index, American Society of Anesthesiology (ASA) score, length-of-stay (LOS), operative severity, type of procedure, procedure urgency, and malignancy.

Results: 390 patients met inclusion criteria. Of those, 297 (76.2%) had preoperative imaging and height. The median age was 79 years (IQR, 74-83), with an in-hospital mortality of 14.9%. Sarcopenic patients did not differ in terms of age, gender, race, comorbidities, malignancy, ASA, procedure urgency or type, operative severity, or discharge to facility. Sarcopenic patients had longer LOS (14 vs. 11 d; p=0.012), were more likely to require ICU care (67% vs. 50%, p=0.012), and had higher in-hospital mortality (27% vs. 9%; p<0.01). Patients with sarcopenia had higher hazard ratios of mortality at 30d (HR:1.59; 95% CI:1.12-2.29; p=0.01), 90d (HR:1.70; CI:1.19-2.44; p<0.01), 180d (HR:1.58; CI:1.10-2.27; p=0.01) and 1yr (HR:1.64; CI:1.14-2.36; p<0.01).

Survival of elderly patients by sarcopenia after emergency abdominal surgery

Conclusion: Sarcopenia is an independent predictor of mortality in elderly patients undergoing emergent abdominal surgery, and this risk continues long after hospital discharge. Sarcopenia determined by PSA is a relatively simple and objective measure of frailty that can be calculated before surgery to identify particularly vulnerable patients for consideration of less invasive approaches and for improved perioperative counseling.
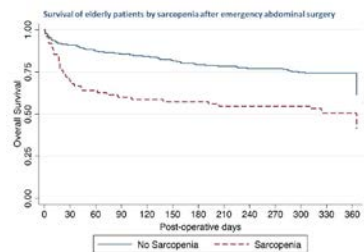
HIGH SENSITIVITY AND SPECIFICITY FOR ULTRASOUND IN THE DIAGNOSIS OF APPENDICITIS

Swathi B. Reddy* MD, Michael Kelleher MD, Jamal Bokhari MD, Kimberly A. Davis* MBA,MD, Kevin M. Schuster* MD,MPH, Yale School Of Medicine

Invited Discussant: Marie Crandall, MD, MPH

Introduction: CT scanning reduces the negative appendectomy rate however it exposes the patient to ionizing radiation. Ultrasound (US) is less commonly used due to a rate of non-visualization of up to 70%. The purpose of this study was to formulate a scoring system to predict appendicitis using US as the only imaging modality using specific US criteria.

Methods: We conducted a retrospective review of all patients (>15 yo) who presented through the emergency department with suspected appendicitis and underwent initial US. An ultrasound score was developed using odds ratios (table) for appendicitis given appendiceal diameter, compressibility, hyperemia, and secondary signs of inflammation including free fluid and focal or diffuse tenderness. If the appendix was not visualized, only secondary signs were documented. The ultrasound score was then combined with the Alvarado score. Final diagnosis of appendicitis was assigned by reviewing pathology reports.

Results: Three hundred patients who underwent US as initial imaging were identified. Thirty-two patients with evident non-appendiceal pathology on US were excluded. In 114 (38%) the appendix was not visualized and partially visualized in 36 (12%). 61 (20.4%) had an appendectomy with 1 (1.6%) negative. Six non-visualized appendicies underwent appendectomy, with no negative cases. Sensitivity and specificity were 86% and 97% at a US score of 1.5. This improved to 98% and 97% respectively for a combined score of 6.5. Area under receiver

ROC Curves for Comparisons

ROC Curve (Area)
Sonographic Score (0.9115)
Alvarado Score (0.9188)
Combined Score (0.9713)

operating characteristic (ROC) curves for our new score were similar to the ROC curve for the Alvarado score (91.9 and 91.1, P = 0.8). The combined US and Alvarado score yielded an AUC of 97.1, significantly better than either score alone (P =0.017 and P < 0.001 respectively).

Conclusion: Our scoring system based entirely on US findings was highly sensitive and specific for appendicitis, and it significantly improved when combined with the Alvarado Score. After prospective evaluation the combined US-Alvarado score might replace the need for CT imaging in a majority of patients.
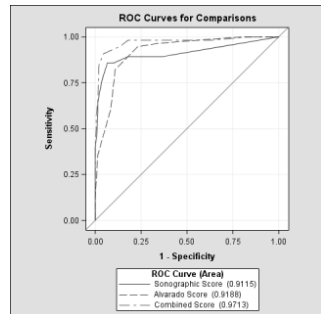
US characteristic	OR	Points
Hyperemia	28.74	1
Non-compressibility	25.50	2
Focal tenderness	176.33	2
Diffuse tenderness	7.67	1
Large free fluid	23.23	1
Small free fluid	2.79	0.5
Size 6-10mm	37.19	1
Size >10mm	680.00	2

Pneumatosis Intestinalis Predictive Evaluation Study (PIPES): A Multicenter Epidemiologic Study of the American Association for the Surgery of Trauma.

Paula Ferrada* MD, Rachael Callcut* MD, Graciela Bauza MD, Karen R. O'Bosky MD, Xian Luo-Owen, Ph.D., Nicky J. Mansfield MD, Kenji Inaba* MD, Jason Pasley DO, Nikolay Bugaev MD, Bruno Pereira MD, Forrest Moore* MD, Jinfeng Han RN, Joseph DuBose* MD, AAST Multi-Institutional Trials Committee

Invited Discussant: Fred Luchette, MD, MSc

Background:
Pneumatosis intestinalis (PI) is associated with numerous adult conditions, ranging from benign to life-threatening. Our group has previously published a retrospective review defining variables predictive of transmural bowel ischemia in the setting of PI. We hypothesize this prospective study will confirm the findings of the retrospective review, enhancing legitimacy to the predictive factors for pathological PI previously highlighted.

Methods:
Demographics, past medical history, clinical presentation and outcomes were collected. The primary outcome was the presence of pathologic PI defined as confirmed transmural ischemia at surgery or in the autopsy report if available when mortality was the final outcome. Forward logistic regression was utilized to identify independent predictors for pathologic PI. Statistical significance was defined as a p-value of ≤ 0.05

Results:
During the 3-year study period, 127 patients with PI were identified. Of these 79 had benign disease and 49 pathological PI defined by the presence of transmural ischemia during surgical exploration or autopsy. Laboratory values such as elevated INR, decreased hemoglobin, and a lactate value of 2.0 or greater, were predictive of pathological PI as well as clinical factors including the presence of an adynamic ileus, peritoneal signs on physical exam, the absence of bowel sounds, sepsis, and hypotension. The Location was also a significant factor, as patients with small bowel PI had a higher incidence of transmural ischemia than PI at colonic locations. As expected patients with pathological PI had an increased hospital length of stay (LOS), ICU LOS, and higher mortality than those patients with benign disease. On multiple logistic regression, a lactate value of 2.0 or greater [OR 5.1, 1.3-19.5, p=0.018], elevated INR [OR 3.2, 1.1-9.6, p=0.031], peritonitis [15.0, 2.9-78, p=0.001], and decreased hemoglobin [0.70, 0.50-0.97, 0.031] remained significant predictors of transmural ischemia [AUC 0.90, 0.83-0.97]. A lactate value of 2.0 or greater and peritonitis are common factors between the retrospective review and this prospective study.

Conclusion:
This is the first multicentric prospective study identifying independent predictors of pathological PI. We recommend surgical exploration to be strongly considered for those PI patients presenting also with a lactate>2 or/and peritonitis

INCREASED ANATOMIC INJURY PREDICTS OUTCOMES: VALIDATION OF AAST EMERGENCY GENERAL SURGERY GRADE IN APPENDICITIS

Matthew Hernandez MD, Johnathon Aho MD, Asad Choudhry MBBS, David Morris*
MD, Martin Zielinski* MD, Mayo Clinic – Rochester

Invited Discussant: Nicole Stassen, MD

Introduction: Determination and reporting of disease severity in emergency general surgery (EGS) lacks standardization. Recently, the American Association for the Surgery of Trauma (AAST) proposed an anatomic severity grading system for EGS diseases. We aim to externally validate this grading system for patients with appendicitis, and if it may be further applied to pre-operative cross sectional imaging to correlate disease severity with AAST severity grade assignment at operation.

Methods: Patients 18 years or older who underwent appendectomy for acute appendicitis between January 2013 - January 2015 were identified. Baseline demographics, preoperative Alvarado scores, procedure types were recorded, and AAST grades were assigned based on intraoperative findings. Cross sectional imaging was assigned AAST grade based on preoperative findings from radiologic reports and independent review. Outcomes including length of stay, 30 day mortality, and complications based on Clavien-Dindo categories were collected. Summary statistical univariate and nominal logistic and standard least squares analyses were performed to compare AAST grade with procedure type, complications, and cross sectional imaging.

Results: A total of 299 patients with a mean ($\pm$SD) age of 37.8 years ($\pm$15.3) were included (52% male) and all patients had preoperative cross sectional imaging. All patients underwent appendectomy, and 94% were completed laparoscopically. Overall 30 day mortality rate was 0%, complication rate was 17%. Calculated operative AAST grade strongly correlated with calculated AAST grade assessed on cross sectional imaging (R 2= 0.82). Mean ($\pm$SD) AAST operative grades were significantly associated with the following key measures associated with disease severity (p<0.0001) procedure type: laparoscopic 1.3 ($\pm$0.05), open 3.6 ($\pm$0.4), conversion to open 3.0 ($\pm$0.3). Increased mean ($\pm$SD) AAST grades was recorded in patients with complications 2.18 ($\pm$0.12) compared to those without 1.34 ($\pm$0.06), p<0.0001.

Conclusions: The AAST EGS grading system was valid in our population and increased AAST grade is significantly associated with open procedures, complications, and length of stay. AAST EGS grade determined by preoperative imaging was strongly correlated to operative AAST grade. Further study aimed at validating AAST anatomic grading in appendicitis prospectively is required.
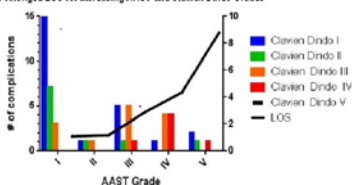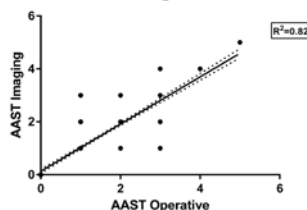
HOSPITALS WITH HIGHER VOLUMES OF EMERGENCY GENERAL SURGERY PATIENTS ACHIEVE LOWER MORTALITY RATES: A CASE FOR ESTABLISHING DESIGNATED CENTERS FOR EMERGENCY GENERAL SURGERY

Gerald Ogola Ph.D., Adil Haider* MD,MPH, Shahid Shafi* MD,MPH, Baylor Scott & White Health System

Invited Discussant: David Hoyt, MD

Introduction: Relationship between higher surgical volume and lower mortality is well established. However, it is not known if this relationship exists in the management of Emergency General Surgery (EGS) diseases. Our hypothesis was that EGS patients treated at hospitals with higher EGS volume experienced lower mortality rates compared to those treated at low volume hospitals.

Methods: This a retrospective analysis of National Inpatient Sample (NIS) data for 2010. NIS is a representative sample of inpatients, maintained by the Agency for Healthcare Quality and Research (AHRQ). Patients with EGS conditions were identified using AAST definition with relevant ICD9 codes (2,640,725 patients from 943 hospitals). For each center, mortality rates were calculated using logistic regression, adjusted for age, sex, race, ethnicity, insurance, and comorbidities. For each hospital, the adjusted mortality rate (percent mortality, 95% Confidence Intervals, CI) was plotted against their EGS volume. Due to nonlinear r elationship between mortality rate and volume, a cubic spline regression model with 4-knots was fitted to estimate volume associated with threshold for low mortality.

Hospitals were also classified by quintiles of annual volume of patients and adjusted mortality rates, and compared with each other.
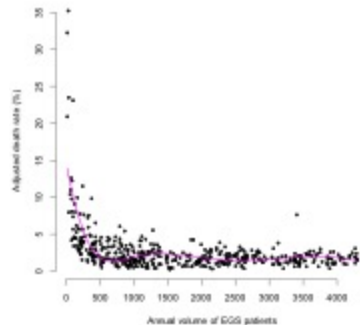
Results: Volume of EGS patients treated at the hospitals was inversely associated with their mortality rates (Figure). Mortality rate in hospitals in the highest quintile of volume (9466±3292 patients) was 1.5% (95% CI 1.4% to 1.6%) compared to those in the lowest quintile of volume (415±240 patients) at 4.6% (95% CI 3.7% to 5.5%) with $p < 0.01$. However, mortality rate appeared to stabilize at an annual volume of 750 patients. Mortality rate in hospitals that treated fewer than 750 patients was 4.9% (95% CI 4.0 to 5.9), compared to those that treated 750 or more patients 1.7% (95% CI 1.6 to 1.8) with $p < 0.01$.

Conclusion: EGS patients treated at hospitals with higher volume of EGS patients experienced lower mortality rates, with a possible threshold of 750 patients per year. The findings suggest that establishing designated EGS centers, similar to designated trauma centers, may improve outcomes of EGS patients.

Circulating syndecan-1 detect the development of disseminated intravascular coagulation in patients with sepsis

Mitsunori Ikeda MD, Hisatake Matsumoto MD, Hiroshi Ogura Ph.D., Tomoya Hirose MD, Kentaro Shimizu Ph.D., Kouji Yamamoto Ph.D., Takeshi Shimazu* Ph.D., Osaka University Graduate School of Medicine

Invited Discussant: Sonlee West, MD

Introduction: Sepsis is a major cause of death in intensive care unit. One of the pathophysiological process in sepsis is endothelial dysfunction, and it induces disseminated intravascular coagulation (DIC). Syndecan-1 is a major structure of endothelial barrier and plays a key role as a target for inflammatory mediators within the acute phase of the endothelial dysfunction. The purpose of this study is to investigate the clinical significance of syndecan-1 and to explore the association between syndecan-1 levels and DIC in patients with sepsis.

Methods: We perform a prospective observational study of patients with severe sepsis and septic shock greater than 18 years from February 2014 to July 2015. Blood samples were collected from patients on days 1, 2, 4, 6, 8, 11 and 15 after the diagnosis of sepsis and from healthy volunteers. The concentrations of syndecan-1, endothelial markers (VCAM-1, PAI-1), inflammatory markers (IL-1β,IL-6 , HMGB-1,Histone H3) were measured using an enzyme-linked immunosorbent assay kit. The 28-day survival data and ISTH overt DIC diagnostic criteria algorithm for assessing DIC over all time points were collected.

Results: During the study, 39 sepsis patients and 15 healthy volunteers were included. The syndecan-1 levels were significantly increased in patients with sepsis compared with healthy controls ($p<0.001$). Of the sepsis patients, non-survivors had significantly higher syndecan-1 levels than those of survivors ($p <0.01$). The syndecan-1 levels on day 1, 2, 4 were significantly higher in patients with DIC than those without. Cox regression analysis showed that the maximal levels of syndecan-1 on day 1, 2, 4 were significantly correlated with the 28-day mortality (hazard ratio 1.001, $p<0.001$) and the development of DIC (hazard ratio 1.0005, $p =0.012$). Significant correlations were also found between the syndecan-1 and DIC score, IL-1β, IL-6 and lactate over three time points (day 1, 2, 4).

Conclusion: We demonstrated for the first time that the syndecan-1 levels in acute phase had significant correlation with DIC in sepsis, suggesting it would be an important marker of the development of DIC.

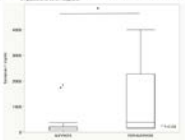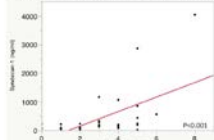Figure1. Comparison of Syndecan-1 levels between survivors and non-survivors in patients with sepsis.

Figure2. Comparison of Syndecan-1 levels between DIC and non DIC in patients with sepsis.

Figure3. Correlation between syndecan-1 levels and ISTH DIC score

International Rotations: A Valuable Resource to Supplement Operative Experience for Acute Care Surgery, Trauma and Surgical Critical Care Fellows.

Paula Ferrada* MD, Rao R. Ivatury* MD, David A. Spain* MD, Kimberly A. Davis* MBA, MD, Michel Aboutanos* MD,MPH, John J. Fildes* MD, Thomas Scalea* MD, Multi Organization Study: Critical Care Program Directors And Acute Care Surgery Program Directors

Invited Discussant: Martin Croce, MD

Introduction: Acute Care Surgery (ACS), Trauma and Surgical Critical Care (SCC) fellowships graduate fellows deemed qualified to perform complex cases immediately upon graduation. We hypothesize international fellow rotations (IFR) can be a resource to supplement operative case exposure

Methods: A survey was sent to all program directors of ACS and SCC fellowships via email. Data was captured and analyzed using the Research Electronic Data Capture (REDCap) tool. The survey included RRC approved SCC fellowships and a variety of trauma and ACS fellowships, some verified by the AAST. Available case logs from 3 IFR of a Trauma Society were reviewed to verify the operative experience.

Results: The survey was sent to 113 program directors (PDs) with a response rate of 42%. The types of fellowship included were: 1 year critical care with some trauma exposure (10.6%), 1 year critical care with significant trauma exposure (25.5%), 2 years including critical care and trauma exposure (4.3%), 2 year critical care, trauma and emergency surgery fellowship non-AAST (23.4%), and 2 year AAST ACS certified (36.2%). The majority of programs trained 2 fellows or less (68%). Most fellows performed < 150 operative cases (59.5%). The majority of PDs thought the operative exposure could either be improved or was not enough to ensure expertise in trauma and emergent general surgery (can be improved 42.6%, not enough 29.8%). Most PDs thought an international experience could supplement the breath of cases, provide research opportunities, and improve understanding of trauma systems worldwide (70%). Barriers to these rotations include lack of contacts in other countries, safety, and economic concerns. A total of 10 sites offered international rotations as part of the curriculum, most of them having the time away built in as an elective in the program (70%). Most programs have funding for these rotations but in 20% of these programs the fellows have to cover their own expense. Most fellowship directors agreed the fellows' experience abroad was excellent and consistent over time (70%) and most fellowship directors perceived that for their fellows, these experiences were worth the cost, effort and the time away from family (80.0%). Most fellowships would be willing to provide reciprocity to the international program where their fellows are sent to train (90%).Operative case logs from IFRs averaged 39 cases per week with the following distribution: Elective(n= 89) cases, Emergency general surgery (n= 36), Trauma including abdominal and thoracic (n=33), major burn wound debridement ± skin grafting (n=114).

Conclusions: The majority of PDs for ACS, trauma, and SCC programs perceive a need for increased quality and quantity of operative cases. The majority also identify IFR as a valuable tool to supplement fellows' education. Consistent funding sources remain a barrier for offering this educational opportunity.

IMPAIRED ADIPONECTIN TRANSPORT CAPACITY IN LEUKOCYTES FROM CRITICALLY ILL PATIENTS

Yutaka Umemura MD, Kentaro Shimizu MD, Hiroshi Ogura* MD, Jinkoo Kang MD, Norikazu Maeda MD, Tohru Funahashi MD, Iichiro Shimomura MD, Koh Taichin MD, Takeshi Shimazu* MD, Osaka University Graduate School of Medicine

Invited Discussant: Jon Simmons, MD

Introduction: Deficiency of adiponectin, adipose derived cytokine with strong anti-inflammatory property, has been reported to affect metabolic syndrome, such as atherosclerosis and type 2 diabetes mellitus. Recent study suggests that adiponectin is localized on the surface of leukocyte adherent to endothelial cells in injured tissue and can promote tissue repair. However, exact role and kinetics of adiponectin in the acute phase of systemic inflammatory response syndrome (SIRS) have not been fully understood. We aimed for the first time to evaluate whether the transport capacity of adiponectin was impaired in critically ill patients.

Methods: This study prospectively included 16 healthy volunteers and 31 SIRS patients, including 16 patients with sepsis and 8 patients with severe trauma (Injury Severity Score; ISS > 16), admitted to a tertiary referral hospital in Japan. The levels of adiponectin combined with monocytes and lymphocytes and the levels of three kinds of adiponectin receptors (receptor 1, receptor 2, cadherin) on the surface of these leukocytes were measured using the flow-cytometry. Data is shown as mean ±standard deviation. We also evaluated the correlation between the transport capacity of adiponectin and severity of illness.

Results: In 31 SIRS patients, the level of adiponectin combined with leukocytes was significantly lower compared to that in healthy volunteers (119.3 ±48.6 vs. 258.1 ±51.1, $p<0.001$ in monocytes and 113.5±41.0 vs. 214.4±38.8, $p<0.001$ in lymphocytes, mean fluorescence/cell). Also, the levels of receptor 2 and cadherin on the surface of monocytes were significantly lower in SIRS patients (707.7±233.6 vs. 1088.6±354.1, $p<0.001$ and 181.2±86.8 vs. 286.5±101.4, $p = 0.006$ respectively). In the subgroup with severe trauma, similar trends were observed, and in addition, the levels of adiponectin combined with monocytes negatively correlated to the ISS (correlation coefficient: 0.65).

Conclusion: We demonstrated that the transport capacity of adiponectin was impaired in SIRS patients. The deficient adiponectin transport to injured tissue may delay the recovery from critical illness.

FACING THE FACTS ON PROPHYLACTIC ANTIBIOTICS AND FACIAL FRACTURES: ONE DAY OR LESS

Brenda M. Zosa MD, Charles W. Elliott BS, Freedom Johnson MD, Jeffrey A. Claridge* MD, MS MetroHealth Medical Center

Invited Discussant: Heather Evans, MD

Introduction: There is no clear evidence for the use of prophylactic antibiotics in preventing infections in the critically injured patient with facial fractures (fx) and practice is highly variable. We compared outcomes in critically injured patients with facial fx who received a short course of antibiotics upon admission to those who received an extended course.

Methods: All adult patients admitted (2010–2015) to a level 1 trauma center intensive care unit with at least 1 facial bone fracture were included. Patients with concomitant head and neck injuries were included. However, patients with significant injuries in any other body region were excluded. Our primary analysis compared infectious complications of the head or neck (H/N infx) between patients given an initial short course of antibiotics, defined as less than 24 hours of antibiotics upon admission, to those given an extended course, defined as greater than 24 hours of antibiotics duration. Multivariate logistic regression (MLR) and analysis of propensity score matched pairs was performed.

Results: There were 403 patients included in this study. 345 patients (85.6%) had blunt injuries. 293 patients (72.7%) had facial fx managed non-operatively. Overall H/N infx rate was 11.2%. Upon admission, 280 patients received a short course of antibiotics and 123 patients received an extended course. Mean ISS (14) was similar between the 2 groups. Patients who received an extended course of antibiotics were younger (47.8 vs 53.8 years, p= 0.011), more likely to be male (79.7% vs 68.6%, p= 0.023), have a penetrating injury (33.3% vs 6.1%, p< 0.001), have fx in multiple facial thirds (51.2% vs 25.0%, p< 0.001), and less likely to have traumatic brain injury (72.5% vs 50.4%, p< 0.001). Patients who received an extended course of antibiotics had higher rates of H/N infx (20.3% vs 7.1%, p< 0.001) and any infection overall (30.9% vs 15.7%, p = 0.001) when compared to those who received a short course. Factors associated with development of H/N infx in the overall population are illustrated in Table 1. MLR identified younger age (OR=0.977, 0.958-0.997, p=0.021), multiple facial third fxs (OR=4.918, 2.378-10.169, p< 0.001), and penetrating mechanism (OR=3.056, 1.468-6.361, p=0.003) as independent predictors of H/N infx. Subgroup analysis of blunt, penetrating, operatively managed, and patients with multiple facial third fx revealed similar results. Additional propensity-score matched analysis of 80 pairs of patients found no differences in H/N infx between short and extended antibiotic courses (11.3% vs 15.0%, p= 0.640).

Conclusions: Extended courses of prophylactic antibiotics did not reduce infections, even in the highest risk patients. Based on our results, we do not recommend more than 24 hours of antibiotics upon admission for facial fx.

Table 1. Factors Associated with H/N Infx			
	No H/N Infx (n=358)	H/N Infx (n= 45)	*p* value
Mean Age (years)	54	39	<0.001
Open Fx	15%	47%	<0.001
Upper Face Fx	21%	47%	0.001
Mandible Fx	17%	60%	<0.001
Penetrating Injury	11%	40%	<0.001
Vascular Injury	3%	16%	0.002
Fxs in >1 Facial Third	28%	73%	<0.001
Hypertension	34%	13%	0.004
Extended abx course	27%	56%	<0.001

A predictor of mortality right under the nose: Measuring sarcopenia in elderly trauma patients using head CT

James D. Wallace MD, Richard Y. Calvo Ph.D., Paul R. Lewis DO, Jason B. Brill MD, Michael J. Sise* MD, C. Beth Sise RN, Steven R. Shackford* MD, Vishal Bansal* MD, Scripps Mercy Hospital Trauma Service

Invited Discussant: Zara Cooper, MD, MSc

Introduction: Sarcopenia, the degenerative loss of skeletal muscle mass, can be measured by computed tomography (CT) scan. Decreased psoas muscle cross sectional area (P-Area) on abdominal CT scan is associated with increased risk for mortality in elderly trauma patients. Fall is the most common mechanism of injury in the elderly, consequently CT imaging of the head is obtained more often than CT imaging of the abdomen. Masseter muscle cross sectional area (M-Area) can be conveniently measured on routine head CT imaging. We compared the utility and feasibility P-Area versus M-Area as markers of sarcopenia and increased risk of mortality in elderly trauma patients.

Methods: All blunt-injured patients aged ≥65 years admitted to our urban level I trauma center during the 2010 calendar year were included. Post-discharge mortality was identified by matching records to county and state death indices as well as the Social Security Death Index. Admission head CT scans were retrospectively reviewed, using standard hospital imaging software, to measure bilateral M-Area two centimeters below the zygomatic arch. Bilateral P-Area was similarly measured using abdominal CT at the level of the fourth vertebral body. Average M-Area and P-Area values were calculated for each patient. Cox proportional hazards models were constructed to evaluate the relationship of M-Area and P-Area with two-year mortality, adjusting for relevant covariates. Model predictive performance was calculated using concordance statistics.

Results: Among 487 patients, bilateral measurements were identified in 403 (82.8%) patients for M-Area and 226 (46.4%) patients for P-Area. On average, females had significantly smaller M-Area (3.40 cm 2 v 4.14 cm2; p<.05) and P-Area (6.49 cm2 vs 10.7 cm2; p<.05) than males. M-Area correlated well with P-Area (r: 0.41, p <0.001). There were no differences in post-discharge mortality by gender. After adjusting for age, gender, injury severity score, and pre-existing conditions, multivariable Cox regression models revealed decreased survival associated with declining M-Area (HR: 0.79, 95% CI 0.63-0.99) and P-Area (HR: 0.88 95% CI 0.78-0.99). M-Area and P-Area performed equally well in best-fit models (0.66, 95% CI 0.61-0.71) vs (0.69, 95% CI 0.63-0.75).

Conclusion: In elderly trauma patients, M-Area is an equally valid and more readily available marker of sarcopenia and 2 year mortality than P-Area. Future study is needed to optimize this novel metric, which could aid in the early identification of at-risk patients who may benefit from aggressive multidisciplinary nutritional interventions and rehabilitation.

Impact of a Novel PI3-Kinase Inhibitor in Preventing Mitochondrial DNA Damage and Damage Associated Molecular Pattern Accumulation: Results from the Biochronicity Project

George Black MD, Matthew Martin* MD, Jon Simmons* MD, David Muscat BS, Victor Pastukh Ph.D., Gina Capley MS, Olena Gorodnya MS, Mykhaylo Ruchko Ph.D., Mark Gillespie Ph.D., University of South Alabama

Invited Discussant: Zsolt Balogh, MD

Introduction: Despite improvements in the management of severely injured patients, development of multiple organ dysfunction syndrome (MODS) remains a morbid complication of traumatic shock. One of the key attributes of MODS is a profound bioenergetics crisis, for which the mediators and mechanisms are poorly understood. We hypothesized that metabolic uncoupling using an experimental PI3-kinase inhibitor, LY294004 (LY), may prevent mitochondrial abnormalities that lead to the generation of mitochondrial DNA (mtDNA) damage and the release of mtDNA damage associated molecular patterns (DAMPs) **Methods**: 16 swine were studied using LY294002 (LY), a non-selective PI3-KI: Animals were assigned to Trauma only (TO, N=3); LY drug only (LYO, N=3); and Experimental (N=10), trauma + drug (LY+T) groups. Both trauma groups underwent laparotomy, 35% hemorrhage, severe ischemia/reperfusion injury, and protocolized resuscitation.. A battery of hemodynamic, laboratory, histologic, and bioenergetic parameters were monitored. mtDNA damage was determined in lung, liver, and kidney using Southern blot analyses, while plasma mtDNA DAMP analysis employed PCR amplification of a 200 bp sequence of the mtDNA D-loop region.

Results: Relative to control animals, H+I/R produced severe, time dependent decrements in hepatic, renal, cardiovascular, and pulmonary function accompanied by severe acidosis and lactate accumulation indicative of bioenergetics insufficiency. The H-I/R-animals displayed prominent oxidative mtDNA damage in all organs studied, with the most prominent damage in the liver. mtDNA damage was accompanied

by accumulation of mtDNA DAMPs in plasma. Pre-treatment of H+I/R animals with LY294002 resulted in profound metabolic suppression, with approximate 50% decreases in O2 consumption and CO2 production. In addition, it prevented organ and bioenergetic dysfunction and was associated with a significant decrease in plasma mtDNA DAMPs to the levels of control animals (FIGURE). **Conclusion**: These findings show that H+I/R injury in anesthetized swine is accompanied by MODS and by significant mitochondrial bioenergetic dysfunction, including oxidative mtDNA damage and accumulation in plasma of mtDNA DAMPs. Suppression of these changes with the PI3K inhibitor LY294002 indicates that pharmacologically-induced metabolic uncoupling may comprise a new pharmacologic strategy to prevent mtDNA damage and DAMP release and prevent or treat trauma-related MODS.
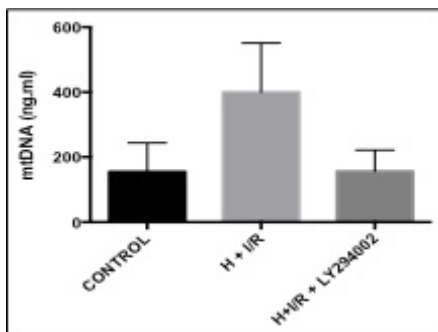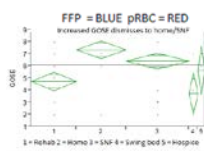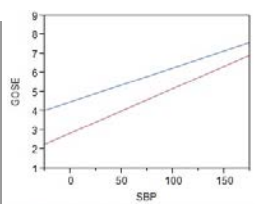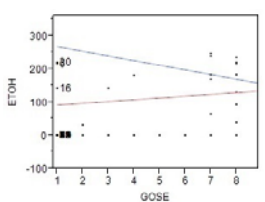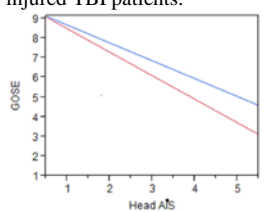
PREHOSPITAL PLASMA RESUSCITATION ASSOCIATED WITH IMPROVED NEUROLOGIC OUTCOMES IN TRAUMATIC BRAIN INJURY

Matthew C. Hernandez MD, Cornelius Thiels DO, Kathleen Berns RN, Elizabeth Habermann Ph.D., Martin Zielinski* MD, James Stubbs MD, Donald Jenkins* MD, Scott Zietlow* MD, Mayo Clinic – Rochester

Invited Discussant: TBD

Introduction: Trauma related coagulopathy and hypotension worsen secondary brain injury in polytrauma patients with TBI. Remote damage control resuscitation with blood products has been shown to be important both for mitigating hypotension and coagulopathy. Early administration of plasma may correct coagulopathies and reduce hypoperfusion. The Glascow Outcomes Score Extended (GOSE) and Disability Rating Scale (DRS) are validated scoring systems used to assess neurologic outcomes in TBI. We aim to compare the neurologic and functional outcomes of unstable patients with TBI receiving early resuscitation in the prehospital setting with either packed red blood cells (pRBC) or fresh frozen plasma (FFP). **Methods**: We identified all polytrauma patients > 15 years old with head abbreviated injury score (AIS) > 1 that underwent prehospital resuscitation with blood products between January 2002 and December 2013 using our Level I trauma center's prospectively collected trauma registry. Those who died in hospital, and those using warfarin were excluded. Glasgow Outcome Score Extended and Disability Rating Score at dismissal were calculated. Patients that received exclusively pre-hospital pRBC were compared to those receiving only FFP using ANOVA and multivariable standard least squares analyses.
Results: 77 patients met inclusion criteria, of whom 52% (n=40) received pre-hospital pRBC and 48% (n=37) received only FFP. There was no significant difference in patient age, gender, injury severity (severity of TBI, head AIS, GCS, head injury diagnosis, ISS), laboratory values on arrival to the ED (hemoglobin, INR, lactate), number of units of prehospital blood product given or length of stay (all p>0.05). Improved neurologic outcomes, a higher mean GOSE, was found in patients receiving FFP than those receiving pRBC (6.59 ±0.32 vs 5.62 ±0.31 p=0.04). Additionally, improved functionality, a lower mean DRS, was in patients that received FFP (4.32 ±0.71) compared to pRBC (7.1 ±0.91, p=0.02). Standard least squares regression demonstrated the following factors were independently associated with a decreased GOSE at dismissal: blood alcohol level >150 mg/dL (p=0.04), systolic blood pressure less than 118 mmHg (p<0.001), use of pRBC (p=.02), head AIS of greater than 3 (p<0.001), platelet count less than 194 x 109 per liter (p=0.005), and maximum amplitude on thromboelastography of less than 40 mm (p=0.02). **Conclusion**: In critically injured trauma patients with TBI, early resuscitation with FFP is associated with improved neurologic and functional outcomes at discharge compared to pRBC. Given the relatively poor outcomes of polytrauma patients with severe TBI, any improved in neurologic outcomes warrants further research. These data, although preliminary, support the use of FFP in the resuscitation of critically injured TBI patients.

FFP = BLUE pRBC = RED

FFP = Blue pRBC = RED

FFP = BLUE pRBC = RED

FFP = BLUE pRBC = RED
Increased GOSE dismisses to home/SNF

1 = Rehab 2 = Home 3 = SNF 4 = Swing bed 5 = Hospice

SYNDECAN-1: A QUANTITATIVE MARKER FOR THE ENDOTHELIOPATHY OF TRAUMA

Erika Gonzalez Rodriguez MD, Sisse R. Ostrowski MD, DMSc, Jessica C. Cardenas Ph.D., Lisa A. Baer BSc, Jeffrey S. Tomasek MD, Hanne H. Henriksen BSc, Jakob Stensballe MD,Ph.D., Bryan A. Cotton* MD,MPH, John B. Holcomb* MD, Pär I. Johansson MD, DMSc, Charles E. Wade* Ph.D., University of Texas Health Science Center-Houston

Invited Discussant: Rosemary Kozar, MD, PhD

Introduction: The endotheliopathy of trauma (EoT) is a consequence of the downstream effects of hemorrhagic shock on the endothelial glycocalyx (EGL) and has been associated with increased mortality. We hypothesized that plasma syndecan-1, as a systemic marker of EGL breakdown, could be used to quantify EoT, potentially leading to the earlier identification of patients in need of endothelial repair.

Methods: Following IRB approval, we prospectively collected plasma samples from 410 trauma patients at the time of emergency room (ED) admission at our level-1 trauma center. Initial vital signs, routine biochemistries, injury severity scores (ISS) and outcomes were recorded. We quantified shed syndecan-1 and soluble thrombomodulin (sTM) from plasma. Receiver operating characteristic curve (ROC) analysis was used to determine the cutoff value of syndecan-1 that maximized the sum of sensitivity and specificity in predicting in-hospital mortality. Through ROC analysis (area under the curve =0.71, sensitivity=0.62, and specificity =0.73), we defined patients as EoT+ based on a syndecan-1 level of > 40 ng/ml (EoT- 40 ng/ml or less). Non-parametric statistical tests were used to assess differences between groups.

Results: Of the 410 patients evaluated, 34% (n=138) were EoT+ (66% were EoT-). Demographic data were comparable between groups. EoT+ patients had an increase incidence of blunt injury and higher ISS (Table). While they were admitted with a lower SBP, no differences in BE or Hgb were detected. Despite

		No EoT (n=272)	EoT+ (n=138)
Arrival signs and labs	Syndecan-1 (ng/ml)	17 (10,26)	108 (61,227)
	% Blunt Injury	67.9%	78.9%*
	SBP (mmHg)	128 (110, 115)	119 (91, 140)*
	Base Excess (mEq/l)	-2 (-5, 1)	-3 (-7, 1)
	Hemoglobin (g/dl)	13.2 (11.9, 14.4)	13.0 (11.2, 14.5)
Morbidity and mortality	ISS	16 (9, 25)	21 (10, 30)*
	% Transfused Blood	36.4%	71.7%*
	% Mortality	12.9%	25.4%*

*Significantly different between groups p<0.05.

subtle differences in ED vital signs, a higher proportion of EoT+ patients required blood transfusions. The EoT+ group had a six fold increase in syndecan-1 levels and a doubling of mortality compared to the EoT- group (Table); both p<0.05. sTM level was independently associated with EoT+ ($p<0.001$) further confirming endothelial damage.

Conclusion: A syndecan-1 level >40 ng/ml identified a group of patients with endothelial dysfunction (EoT) in the absence of definitive differences in admission physiology. EoT is associated with an increased requirement for transfusion of blood products and substantially increased mortality. Early EoT identification could target endothelial rescue therapy with the potential to improve outcome, but this warrants further research.

DAMAGE CONTROL LAPAROTOMY UTILIZATION RATES ARE HIGHLY VARIABLE AMONG LEVEL 1 TRAUMA CENTERS: PROPPR FINDINGS

Justin J. Watson MD, Jamison Nielsen DO, MBA, Kyle Hart MS, John Yonge MD, Christopher Connelly MD, Phillip Kemp Bohan BA, Hillary Sosnovske Barbara Tilley Ph.D., Gerald Van Belle Ph.D., Bryan Cotton* MD, MPH, Terence S. O'Keeffe* MD, MPH, Eileen Bulger* MD, Karen Brasel* MD, MPH, John Holcomb* MD, Martin Schreiber* MD, Oregon Health & Science University

Invited Discussant: Ben Zarzaur, Jr., MD, MPH

Introduction: Damage control laparotomy (DCL) is intended to limit deleterious effects from trauma induced coagulopathy. In cohort studies, DCL has been associated with a reduction in mortality, though there is increased risk for sepsis, abdominal abscess, respiratory failure, acute renal failure, ventral hernia and gastrointestinal fistula. We hypothesized that (1) DCL incidence would vary by institution; (2) mortality rates would correlate with DCL rates; (3) standard DCL criteria of pH, INR, temperature and major intra-abdominal vascular injury (MVI) would not adequately capture all patients receiving DCL.

Methods: Severely injured patients predicted to receive a massive transfusion admitted to 12 level 1 North American trauma centers were randomized based on transfusion ratios as described in the PROPPR trial. We analyzed patients that underwent an emergency laparotomy using a mixed-effects model with random effect for study site to compare patient outcomes after DCL versus closed definitive surgical management (DSM). Primary outcomes were 24-hour and 30-day mortality.
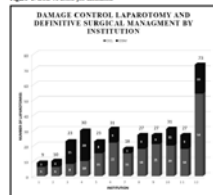
Results: 329 total patients underwent emergent laparotomy. 213 underwent DCL (65%) while 116 underwent DSM (35%). Patients undergoing DCL per institution ranged from 6-54 (33%-83%). Median ISS was higher in the DCL group, 29 (IQR: 13,34) versus 21 (IQR: 22,41) (p<0.001). Odds of having a DCL varied between sites (p=0.002). In a mixed-effects model, ISS and MVI were significant predictors of DCL (OR: 1.05, 95% CI: 1.02-1.07 and 2.7, 95% CI: 1.4-5.2) but mechanism was not. 24-hour mortality with DSM was 4%, versus 19% with DCL (p<0.001); 30-day mortality was 19% with DSM versus 28% with DCL (p<0.001). In a mixed-effects model of 30-day mortality, DCL was associated with death (OR: 2.54, 95% CI: 1.21-5.32, p=0.014). Other predictors included ISS and age (OR: 1.06, 95% CI: 1.04-1.09 and 1.03, 95% CI: 1.01-1.04). Blood treatment group, sex, and mechanism were not predictors of mortality. In both univariate and multivariable analyses there was no difference in 30-day mortality between institutions. The proportion of patients meeting any standard criteria for DCL was 135/213 in those receiving DCL (80%) and 53/116 (67%) i n those with DSM. Only INR > 1.5 (30% vs 6% p<0.001) and MVI (31% vs 16% p=0.003) was higher in DCL vs DSM while temperature and pH were similar. Sepsis (p<0.001) and VAP (p=0.02) occurred more frequently in DCL patients while MOF trended towards significance (p=0.06).

Table 1. Mixed-effects logistic regression model of 30-day mortality with a random effect for study site, N=319

	OR (95% CI)	p-value
DCL	2.54 (1.21, 5.32)	0.013
Blood group 1:1:2 (vs 1:1:1)	1.67 (0.92, 3.04)	0.094
Male	0.89 (0.44, 1.82)	0.758
Age (per year increase)	1.03 (1.01, 1.04)	0.004
ISS (per unit increase)	1.06 (1.04, 1.09)	<0.001
Penetrating (vs blunt) mechanism	1.19 (0.61, 2.32)	0.606

Figure 1. DCL vs DSM per institution
DAMAGE CONTROL LAPAROTOMY AND DEFINITIVE SURGICAL MANAGMENT BY INSTITUTION

Conclusions: There is significant variation in DCL utilization between institutions. Despite this variance, there is no significant mortality difference detected between centers. DCL was associated with higher ISS, 30-day mortality, and morbidities including sepsis and VAP. Standard criteria only capture 80% of patients receiving DCL.

CLINICAL CORRELATES TO ASSIST WITH CTE DIAGNOSIS: INSIGHTS FROM A NOVEL RODENT REPEAT TBI MODEL

Gretchen Thomsen Ph.D., Annie Ma BS, Ara Ko MD, Megan Harada BS, Patricia Haro
Jean-Philippe Vit Ph.D., Eric Ley* MD, Cedars-Sinai Medical Center

Invited Discussant: Michael Dubick, PhD

Introduction: Chronic traumatic encephalopathy (CTE) is a neurodegenerative disease linked to repetitive mild head injuries. Symptoms of CTE include changes in mood, behavior, cognition and motor function. However, CTE is only currently diagnosed post-mortem based on significant brain atrophy and the accumulation of phosphorylated tau (P-tau) within the cerebral cortex. As there is no strict clinical test for CTE and there is a lack of animal model that accurately represents this condition, understanding the mechanisms involved and therefore developing treatments is problematic. Here, we show that a novel rat model of recurrent traumatic brain injury (TBI) leads to permanent deficits in balance and motor function and that the degree of functional deficit predicts the severity of CTE-like brain pathology.

Methods: A total of 20 wild type (WT) rats were examined over a 12- or 25-week study period. At postnatal day 60, bilateral, closed skull, mild TBI was administered to 14 WT rats. 4 rats received 2, once-weekly TBI ("2TBI"), 10 rats received 5, once-weekly TBI ("5TBI") and 6 rats were used as sham controls. Rats were euthanized either 12 or 25 weeks following their first injury. Behavioral tasks including rotarod, rearing activity and BBB scoring for assessment of limb paralysis were performed at week 6. Deficits in these tasks relative to sham controls were classified as "strong", "mild/moderate", or "none". Upon euthanasia, brain tissue was collected and stained for P-tau using an AT8 antibody (Thermofisher MN1020). Qualitative assessment of P-tau levels was performed and were designated with "+" (mild P-tau pathology, limited to superficial cortical layers around midline), "++" (mild/moderate P-tau pathology, extending into the deep cortical layers but localized near midline), or "+++" (widespread P-tau pathology, extending throughout the entire cortex). Cortical and corpus callosum thickness was calculated by averaging 3 measurements in each of 5 sections for each rat. Values presented are the percent difference relative to sham controls. Significance was defined as p value <0.05 (*).

Results: 5TBI rats euthanized at 25-weeks post-first injury with strong deficits in rotarod, rearing activity, and limb paralysis had 34% ± 2 cortical shrinkage and 68% ± 3 shrinkage of the corpus callosum, relative to sham controls. This is compared to 11% ± 6 cortical shrinkage and 33% ± 8 corpus callosum shrinkage observed in 5TBI rats also euthanized at 25-weeks, but presenting with mild/moderate deficits in rotarod, rearing activity and limb paralysis. 5TBI rats euthanized at 12-weeks post first injury that exhibited strong deficits in rotarod, rearing activity and limb paralysis had 25% ± 2 cortical shrinkage and 29% ± 3 corpus callosum shrinkage. 2TBI rats euthanized at 12-weeks post-first injury that had no deficits in rotarod, rearing activity, or limb paralysis, had 14% ± 8 cortical shrinkage and 22% ± 8 corpus callosum shrinkage. Upon histological exam, all rat brains with strong deficits had significant P-tau pathology relative to sham whereas mild/moderate and those with no deficits appeared to have increased P-tau levels relative to sham but reduced levels relative to those rats with strong behavioral deficits (see table below).

Table: Correlation of motor deficits with CTE-like brain pathology						
group	deficit	rotarod	rearing	limb paralysis	cortical shrinkage	corpus callosum shrinkage	tau pathology
2TBI 12-week survival	none	21% ± 10 NS	11% ± 34 NS	5 ± 4 NS	14% ± 8*	22% ± 8*	+
5TBI 12-week survival	strong	76% ± 21*	66% ± 18*	17% ± 6*	25% ± 2*	29% ± 3*	++
5TBI 25-week survival	mild/moderate	49% ± 7*	15% ± 8 NS	2% ± 3 NS	11% ± 6*	33 ± 8*	+
5TBI 25-week survival	strong	96% ± 2*	86% ± 7*	17% ± 7*	34% ± 2*	68% ± 3*	+++

Conclusion: Our model of repeat TBI suggests that permanent deficits in motor function are correlated with CTE-like brain pathology. Testing patients on the basis of balance and motor coordination over time may be a predictive test to diagnose CTE. The use of this model will allow for understanding the mechanisms of CTE and developing therapeutic strategies.

D-DIMER MAY SIGNIFICANTLY REDUCE UNNECESSARY CT SCANS IN PEDIATRIC HEAD TRAUMA: A POTENTIAL FOR PECARN+

Simone Langness MD, Erin Ward MD, Jonathan Halbach DO, Katherine Davenport MD, Stephen Bickler MD, Karen Kling MD, Hari Thangarajah MD, University of California, San Diego

Invited Discussant: Brian Leininger, MD

Introduction: Blunt head trauma in children is responsible for nearly 600,000 emergency room visits annually in the US. Despite this high number, the rates of clinically important traumatic brain injury (ciTBI) are low. Head computed tomography (CT) remains the only definitive test to evaluate for ciTBI and judicious use is advocated to avoid excessive radiation exposure and cost. Clinical prediction rules, such as those developed by the Pediatric Emergency Care Applied Research Network (PECARN), were created to help guide clinicians in CT decision-making. PECARN, however, can be limited by patient age, incomplete history and subjective reports. As such, objective data may be an important addition. Previous work in low volume patient cohorts has suggested that quantitative D-dimer can predict the absence of ciTBI on head CT. We aimed to determine the impact of adding quantitative D-dimer to the PECARN prediction rules in avoiding unnecessary head CT scans following pediatric blunt head trauma.

Methods: Retrospective review was performed for all patients presenting with blunt head injury to our Level I Pediatric Trauma Center from 2011-2013 who underwent evaluation with both CT head and serum D-dimer level. Patients were considered to meet "major" or "minor" PECARN screening criteria in accordance with the PECARN head trauma algorithm (Fig 1).

Figure 1. PECARN Screening Algorithm for CT Scanning After Pediatric Head Injury

Results: Of the 553 patients evaluated for ciTBI with a CT scan and D-dimer, 531 (96%) met PECARN criteria: 36.2% with "major" criteria and 59.9% with "minor" criteria (39.4% of which met multiple "minor" criteria). ciTBI was identified in 79 (14%) patients. D-dimer was >750 pg/uL in all patients with ciTBI. Adding a "negative" D-dimer to the current PECARN algorithm significantly improved patient selection for CT scanning. Using a D-dimer negative threshold value of <100, <500 and <750 pg/uL would have avoided 106, 173, and 197 head CT scans, respectively, without missing a ciTBI (Fig 2).

Figure 2. Avoided Head CT Scans by Incorporating D-Dimer into PECARN Screening Guidelines

D-Dimer Negative Threshold	<100 pg/uL	<500 pg/uL	<750 pg/uL
Head CT Scans Avoided	106	173	197
% Total Head CT Scans Obtained	19.2%	31.3%	35.6%

Conclusion: Low D-dimer can accurately predict the absence of ciTBI for pediatric patients following blunt head trauma. Incorporating D-dimer into current imaging algorithms can substantially improve patient selection and reduce the number of unnecessary head CT scans obtained for the evaluation of ciTBI.

ABNORMALITIES IN FIBRINOLYSIS ARE ASSOCIATED WITH VENOUS THROMBOEMBOLISM, MORTALITY, AND DISABILITY IN A PEDIATRIC TRAUMA POPULATION

Christine M. Leeper MD, Matthew D. Neal* MD, Christine McKenna CRNP, Jason Sperry* MD,MPH, Barbara A. Gaines* MD, Children's Hospital of Pitsburgh of UPMC

Invited Discussant: R. Todd Maxson, MD

Introduction: Abnormalities in fibrinolysis are associated with increased mortality in adult trauma populations. While hyperfibrinolysis (HF) and the emerging topic of fibrinolysis shutdown (SD) are potential prognostic indicators and treatment targets in adults, these derangements are not well-described in a pediatric trauma cohort.

Methods: Ongoing prospective analysis of highest level trauma activations age 0-18 presenting to our academic center since June 2015 with admission rapid thromboelastogram (TEG). Fibrinolysis shutdown was defined as clot lysis at 30 minutes (LY30) ≤0.8%, and hyperfibrinolysis was LY30≥3.0%. Variables of interest included demographics, admission vitals and labs, injuries, incidence of venous thromboembolism (screening ultrasound is performed for high risk ICU admissions), death and discharge disability (discharge to facility or dependence in functional independence measure category). Data were summarized and Wilcoxon rank-sum test, Chi-square or Fisher exact test were performed.

Results: To date, 75 patients are included: 34% (n=25) had SD on admission; 20% (n=15) had HF and 46% (n=34) of patients fell into normal range. Median age 9 years (3-13), ISS 18 (11-26), 75% blunt mechanism. Overall mortality rate was 9.5% (n=7) and DVT incidence was 10.8% (n=8). SD was significantly associated with elevated admission INR (p=0.022) and incidence of DVT (p=0.002). HF was associated with hemorrhagic injuries (p=0.007). Any abnormality in fibrinolysis (HF+SD) was associated with mortality (p=0.015), discharge disability (p=0.045), and need for packed red blood cell transfusion within 24 hours (p=0.020).

Conclusion: Children demonstrate high rates of inhibition (SD) and overactivation (HF) of fibrinolysis after injury. This significant derangement is associated with poor outcomes compared to physiologic fibrinolysis. Shutdown in particular represents a maladaptive systemic response, with admission coagulopathy and later development of hypercoagulable state. The addition of TEG to empiric transfusion protocols in pediatric centers should be considered as it contributes important prognostic and clinical information that may help tailor patient care.

Derangement in fibrinolysis is associated with poor outcomes in critically-injured children
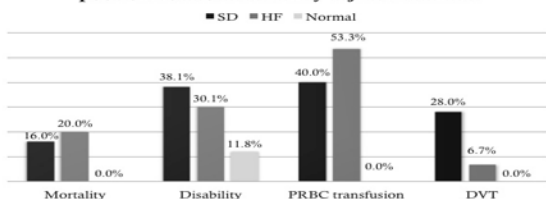
1:1 TRANSFUSION STRATEGIES ARE RIGHT FOR THE WRONG REASON

Stephanie A. Savage* MD, MS, Ben L. Zarzaur* MD,MPH, Brian L. Brewer MD,
Garrett H. Lim BS, Ali C. Martin BS, Louis J. Magnotti* MD, Martin A. Croce* MD,
Timothy H. Pohlman* MD, Indiana Univesity School of Medicine

Invited Discussant: Yasuhiro Otomo, MD

Introduction: Early assessment of clot function in injured patients has identified acute coagulopathies following trauma. These abnormalities include a hypercoagulable state from excess thrombin generation, as well as an acquired coagulopathy due to a rapid depletion of fibrinogen. Efforts to address these abnormalities have resulted in earlier and more aggressive use of plasma, with an emphasis on 1:1 resuscitation. The purpose of this study was to describe these coagulopathies in varying hemorrhagic phenotypes from a cohort of severely injured patients.

Methods: All patients admitted as Level 1 trauma activations, who received at least one unit of packed red blood cells (PRBC) in the first 24 hours, were eligible for inclusion. Group-based trajectory modeling, using volume of transfusion over time, was used to identify specific hemorrhagic phenotypes within the cohort. The TEG profile of each subgroup was characterized and group features were compared. The primary outcome of interest was mortality.

Results: 330 patients were included. Four hemorrhagic phenotypes were identified –

Figure. Group Trajectories for Blood Resuscitation

Group Percents ••• 32.2   ••• 15.1   ••• 8.9   ••• 43.9

Table. Characteristics of Trajectory Groups

	Group 1	Group 2	Group 3	Group 4	p-value
% Blunt	77%	60%	56%	45%	p<0.05
ISS*	18 (10-29)	22 (13-29)	29 (20-50)	18 (10-28)	p<0.05
Admit SBP*	120 (94-135)	128 (105-143)	93 (49-116)	125 (95-142)	p<0.05
Admit pH*	7.29 (7.23-7.36)	7.33 (7.26-7.38)	7.03 (6.94-7.28)	7.29 (7.16-7.37)	p<0.05
Admit PTT*	27.5 (24.7-32.6)	28.6 (24.4-36.5)	36.7 (28.1-55.5)	26.4 (23.1-30.9)	p<0.05
# CAT+*	0.5 (0-2)	1 (0-2)	7 (6-10)	1 (0-2)	p<0.05
Total PRBC*	4 (3-8)	6 (4-10)	23 (19-31)	4 (2-8)	p<0.05
Total FFP*	2 (0-4)	2 (0-4)	15 (8-23)	0 (0-4)	p<0.05
Mortality	18%	30%	56%	16%	p<0.05

*reported as median (IQR)

minimal (group 1); patients with large PRBC requirements later in the hospital course (group 2); massive PRBC usage (group 3) and PRBC transfusion limited to shortly after injury (group 4)(*Figure*). All patients were severely injured with an ISS >18. All groups had an R-time shorter than the normal range (3.2-3.5, p = NS). Patients in group 3 had longer K-times (1.8 vs. 1.2-1.3, p<0.05), significantly flatter alpha angles (66.7 vs. 70.4-72.8, p<0.05) and significantly weaker clot strength (MA 54.6 vs. 62.3-63.6, p<0.05). Group 3 had greater physiologic derangements at admission and worse overall outcomes(*Table*).

Conclusion: Hemorrhagic phenotypes demonstrate rapid onset of clot formation in all subgroups but significantly suppressed thrombin burst and diminished clot strength in the most injured. This suggests that patients are both hypercoagulable, with early and precipitous clot formation, but that they also have a demonstrable hypocoagulability, potentially due to profound fibrinogen consumption and resultant hypofibringenimia. Survival benefits attributed to plasma may be a primary consequence of its fibrinogen component. Massive transfusion protocols may be more effective if the emphasis is placed on the early use of cryoprecipitate in preference to plasma in select patients.

POPULATION-BASED ESTIMATES OF VIOLENCE-RELATED DEATH RATES FOR LAW ENFORCEMENT PERSONNEL: THE RISK OF DEATH ARE HIGHER AND INCREASING OVER TIME

Alexander L. Eastman* MD,MPH, Michael W. Cripps MD, Kareem R. Abdelfattah MD, Kenji Inaba* MD, Brian H. Williams MD, Christian T. Minshall* MD,Ph.D., Joseph P. Minei* MBA,MD, Kristan L. Staudenmayer* MD, MS UT Southwestern/Parkland

Invited Discussant: William Cioffi, MD

OBJECTIVE: Trauma-related deaths remain an important public health problem. One group susceptible to death from traumatic mechanisms are U.S. law enforcement officers (LEOs). We hypothesized that LEOs experienced a higher chance of violent death compared to the general U.S. population and that their risk has increased over time.
**METHODS:** The National Institute on Occupational Safety and Health (NIOSH) National Occupational Mortality Surveillance (NOMS) is a population-based survey of occupational deaths. It includes data for workers who died during 1985-1998 in one of 30 U.S states (EARLY period). Additional deaths were added from 23 U.S. states in 1999, 2003-2004, 2007 (LATE period). Mortality rates are estimated by calculating proportionate mortality ratios (PMR). A PMR above 100 is considered to exceed the average background risk for all occupations. All adults >18 years of age whose primary occupation was listed as "Law Enforcement Worker" were included in the analysis.
RESULTS: LEOs were more likely to die from an injury compared to the general population (Figure 1). The overall PMR for injury in EARLY was 111 (95% Confidence Interval [CI] 108-114, p<0.01), and for LATE was 118 (95% CI 110-127, p<0.01). Four mechanisms of death reached statistical significance: motor vehicle traffic (MVT)-driver, MVT-other, intentional self-harm, and assault/homicide. All 4 categories increased between time periods. The highest PMR in EARLY was associated with firearms (PMR 272, 95% CI 207-350, p<0.01). The highest PMR in LATE was associated with death due to being a driver in an MVT (PMR 169, 95% CI 136-207, p<0.01). There were differences in risk of death by race and gender. White females had the highest PMR due to Assault and Homicide (PMR 317, 95% CI 164-554, p<0.01). All groups had similar risks of death due to Intentional Self-Harm (PMR 130-171).
CONCLUSIONS: The risk of death for US LEOs is high and increasing over time. This suggests an at-risk population that requires further interventions. Targeted efforts based on risk factors, as well as gender, race and the risk for suicide, may assist with the development of prevention programs for this population.

Figure 1: Motor Vehicle Traffic and Assault Related Mortality for Law Enforcement Personnel
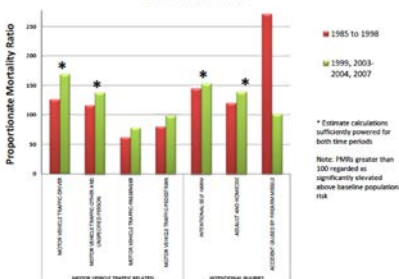
IMPACT OF EARLY OPERATIVE PELVIC FIXATION ON LONG-TERM FUNCTIONAL OUTCOME FOLLOWING SEVERE PELVIC FRACTURE

John P. Sharpe MD, MS, Louis J. Magnotti* MD, Wade C. Gobbell BS, Xin Huang BS, Edward A. Perez MD, Timothy C. Fabian* MD, Martin A. Croce* MD, University of Tennessee Health Science Center – Memphis

Invited Discussant: Walter Biffl, MD

Introduction: Traumatic disruption of the pelvic ring is a significant cause of life-threatening hemorrhage. For those patients who survive the initial injury, these fractures are associated with long periods of immobilization and intense rehabilitation. Despite advancements in fixation techniques, there is little published information available regarding long-term functional outcomes in these patients. This study evaluated the impact of severe pelvic fractures on those long-term outcomes.

Methods: All patients with severe pelvic fractures over an 18-year period (ending September 2014) were identified from the trauma registry. Severe pelvic fractures were defined as those with vascular disruption, open book component with symphysis diastasis, or sacroiliac disruption with vertical shear. Using a telephone interview, functional outcome was measured using the Boston University Activity Measure for Post-Acute Care (AM-PAC) to assess mobility (normal>84) and daily activity (normal>84). Multiple regression analysis was used to identify potential predictors of functional outcome after severe pelvic fracture.

Results: 401 patients were identified: 241 (60%) men and 160 (40%) women. Overall mortality was 29%. Of the 285 survivors, follow-up was obtained in 145 (51%) patients. Mean follow-up was 8.3 years, with a maximum of 20 years. Mean age and injury severity score (ISS) were 53 years and 27, respectively. The mean number of RBC units transfused was 11.2 with an associated ICU length of stay of 13.3 days. Mean AM-PAC scores for mobility and daily activity were 55 and 53, respectively; both demonstrating significant impairment when compared to normal. Multiple regression analysis employing age, traumatic brain injury, transfusions, ISS and time to operative pelvic fixation identified time to pelvic fixation as the only predictor of decreased mobility (β = -0.43, p = 0.045) and activity (β = -0.27, p = 0.015) following severe pelvic fracture.

Conclusion: Prolonged time to operative pelvic fixation led to worse long-term functional outcomes in patients suffering severe pelvic ring disruption. In fact, multiple regression analysis only identified time to pelvic fixation as an independent predictor of significant impairment in both mobility and daily activities. Thus early fixation of the pelvic ring is the only potentially *modifiable* risk factor for decreased functional outcomes in patients with severe pelvic fractures.

CERVICAL SPINE MRI IN PATIENTS WITH NEGATIVE CT: A PROSPECTIVE, MULTICENTER STUDY OF THE RESEARCH CONSORTIUM OF NEW ENGLAND CENTERS FOR TRAUMA (ReCONECT)

Adrian A. Maung* MD, Dirk C. Johnson MD, Kimberly Barre RN, Thomas Peponis MD, Tomaz Mesar MD, George C. Velmahos* MD, Ph.D., George Kasotakis MD,MPH, Ronald I. Gross* MD, Michael S. Rosenblatt* MBA,MD,MPH, Kristen C. Sihler* MD, Robert J. Winchell* MD, Walter Cholewczynski MD, Kathryn L. Butler MD, Stephen R. Odom MD, Kimberly A. Davis* MBA,MD, Yale School of Medicine

Invited Discussant: Kenji Inaba, MD

Introduction: Although cervical spine CT scan (CSCT) accurately detects bony injuries, it may not identify all soft tissue injuries. While some clinicians rely exclusively on a negative CSCT to remove cervical spine precautions in unevaluable patients or patients with midline cervicalgia, others use MRI for that purpose. The objective of this ReCONECT study was to determine the rates of abnormal MRI after a negative CSCT.

Methods: Blunt trauma patients who were unevaluable or had persistent midline cervicalgia and underwent an MRI of C-spine after a negative CSCT were enrolled prospectively in 8 Level I and II New England trauma centers over a 30-month period. Demographics, injury patterns, CT and MRI results, and any changes in cervical spine management were recorded.

Results: 767 patients had MRI because of cervicalgia (43.0%), inability to evaluate (44.1%) or both (9.4%). Mechanisms of injury included ground level fall (32.6%), road collisions (29.6%), fall from height (18.3%) and pedestrian struck (7%). MRI was abnormal in 23.6% of all patients, including ligamentous injury (16.6%), swelling (4.3%), vertebral disc injury (1.4%) and dural hematomas (1.3%). Patients with abnormal MRI were more likely male and were more severely injured (ISS 19 vs. 13, p=0.001). Rates of abnormal neurological signs or symptoms were not different among patients with normal vs. abnormal MRI. (15.2 vs. 18.8%, p=0.25). The c-collar was removed in 88.1% of patients with normal MRI and 13.3% of patients with an abnormal MRI. No patient required halo placement but 14 patients underwent cervical spine surgery after the MRI results. Eight of the fourteen had neurological signs or symptoms.

Conclusion: In a select population of patients with persistent cervicalgia or altered mental status, MRI identified additional disc or soft tissue injuries in 23.6% of patients in whom the final written interpretation of CT scan was normal. It is uncertain if this is a true limitation of CT technology or represents subtle injuries missed in the interpretation of the scan. The clinical significance of these abnormal MRI findings cannot be determined from this study group.

SYSTEMIC INTRAOPERATIVE ANTICOAGULATION DURING MAJOR ARTERIAL INJURY REPAIR: IMPLICATIONS FOR PATENCY AND BLEEDING

Zoe Maher MD, Brian Frank MD, Jeremy W. Cannon* MD, Lisa M. Capano-Wehrle MPH, Elizabeth Dauer MD, Joshua P. Hazelton DO, Andrea Lubitz MD, Huaqing Zhao Ph.D., Mark J. Seamon* MD, Temple University Hospital

Invited Discussant: Ian Civil, MBE, KstJ, ED, MBCHB, FRACS

Introduction: The role of systemic, intraoperative anticoagulation (SIAC) during the surgical repair of major arterial injuries is controversial. Any potential improvement in arterial patency must be weighed against the risk of hemorrhage in these critically injured patients. We hypothesized that SIAC would increase arterial patency without increasing bleeding complications.

Methods: We conducted a multi-institution, retrospective cohort study of trauma patients with major vascular injury from 2005-2013 in 3 urban, level I trauma centers. Arterial injuries of the neck, torso and extremities proximal to the elbows or knees requiring operative management were included. Our primary endpoint was the maintenance of arterial patency during the index hospitalization. Return to OR for bleeding was also assessed. The association between SIAC and arterial patency was evaluated using Chi-Square, t-test, Mann-Whitney U test and multiple logistic regression modeling where appropriate.

Results: Of 323 study patients, most were male (88%) and injured by gunshot (69%). Patients repaired with SIAC (n=154) were compared to those repaired without SIAC (n=169). No difference in age, gender, injury mechanism, admission hemodynamics, time to OR, associated venous injury or fracture was detected between SIAC and no SIAC groups (all p>0.05). Importantly, use of SIAC during arterial repair was associated with greater arterial patency rates (93% vs. 85%, p=0.02) without any increase in return to OR for bleeding (4% vs. 6%, p=0.29). After controlling for ISS, gender, admission hemodynamics, return to OR for revision or bleeding, postoperative anticoagulation and hospital LOS, multiple logistic regression determined that patients repaired with SIAC were three times as likely (OR 3.0, 95%CI 1.04–8.8, p=0.04) to maintain arterial patency as those repaired without. Patients who maintained arterial patency were then less likely to return to the OR (9% vs. 78%, p<0.001) and had shorter ICU (median 3 vs. 9 days, p<0.01) and hospital LOS (median 13 vs. 21 days, p<0.01).

Conclusion: Patients who underwent operative repair of major arterial injuries utilizing SIAC experienced better arterial patency without additional bleeding requiring return to OR as compared to those repaired without SIAC. Our data suggests that 1) SIAC should be utilized during arterial repair and 2) the attributable bleeding risk of SIAC may be overstated.

PREDICTING MORTALITY IN OLDER TRAUMA PATIENTS: A NOVEL METRIC BASED ON PRE-EXISTING CONDITIONS

Richard Y. Calvo MPH, Ph.D., Suzanne P. Lindsay MPH, Ph.D., MSW, Steven D. Edland Ph.D., Caroline Macera Ph.D., Deborah Wingard Ph.D., Lucila Ohno-Machado MD,Ph.D., Michael J. Sise* MD, Steven R. Shackford* MD, Scripps Mercy Hospital Trauma Service

Invited Discussant: Kristan Staudenmayer, MD, MSc

Introduction: Among the growing number of older trauma patients, those with pre-existing conditions (PEC) are at an increased risk of death. We developed a new metric to measure PEC burden that predicts trauma-related mortality among older trauma patients.
Methods: A cohort of 4,561 blunt-injured patients aged ≥55 years with low injury severity (TMPM Probability of Death <50%) admitted to a Level I trauma center from 01/06-12/12 were separated into development (80%) and test (20%) datasets. Trauma-related mortality, defined as death in-hospital or within 90 days of discharge, was captured using national and regional death data. PEC were extracted from the trauma registry and administrative claims data. Cox regression was used to develop our PEC-based model and a PEC risk score. Concordance statistics (c) was used to compare our risk score with others, including two PEC-based metrics (Charlson; Elixhauser) and three injury-based metrics (TRISS; TMPM; RTS). A separate cohort of 2,620 blunt-injured trauma patients aged ≥18 years with all levels of injury severity was used to evaluate our risk score's external validity.
Results: A total of 12 PEC were selected for our final model. In the test set, our risk score (c: 79.7) was superior to Charlson (c: 71.3), Elixhauser (c: 75.0) and all injury-based metrics (TMPM c: 61.8; TRISS c: 34.5; RTS c: 50.3) in predicting trauma-related mortality. For in-hospital mortality, only our PEC risk score demonstrated any appreciable discrimination over a 50% null value (c: 75.4, 95%CI: 58.7-92.1). In the validation set, all three PEC-based metrics demonstrated similar performance (PEC Risk Score c: 66.7; Charlson c: 69.3; Elixhauser c: 68.9) in predicting in-hospital mortality and outperformed all injury-based metrics.
Conclusion: Our 12-item prognostic risk score for trauma-related mortality performed well compared to other metrics. This suggests that the risk of death among older trauma patients is better predicted by PEC than physiologic or anatomic injury severity. Additional validation of our risk score is warranted.

Table. Concordance statistics (95% confidence interval) for mortality by dataset			
Model Type	**Test Dataset**		**Validation Dataset**
	Trauma-related Mortality	In-hospital Mortality	In-hospital Mortality
PEC Risk Score	79.7 (76.7-83.7)	75.4 (58.7-92.1)	66.7 (52.2-81.3)
Charlson	71.3 (65.7-76.8)	59.4 (41.5-77.4)	69.3 (56.8-81.8)
Elixhauser	75.0 (69.8-80.1)	65.2 (47.1-83.2)	68.9 (55.4-82.3)
TMPM	61.8 (55.1-68.5)	44.4 (26.8-62.0)	51.7 (34.3-69.1)
TRISS	34.5 (18.9-50.0)	42.7 (23.4-62.1)	63.1 (47.3-78.8)
RTS	50.3 (38.4-62.2)	52.4 (37.9-66.9)	65.0 (50.7-79.3)

IDENTIFYING AUGMENTED RENAL CLEARANCE IN TRAUMA PATIENTS: VALIDATION OF THE AUGMENTED RENAL CLEARANCE IN TRAUMA INTENSIVE CARE (ARCTIC) SCORING SYSTEM

Jeffrey F. Barletta B.S., Pharm.D., FCCM, Alicia J. Mangram* MD, Marilyn Byrne RN,
Joseph F. Sucher MD, Alexzandra K. Hollingworth MD, Francis R. Ali-Osman MD,
Gina R. Shirah MD, James K. Dzandu Ph.D., Honor Health- John C. Lincoln Medical
Center

Invited Discussant: Lewis Kaplan, MD

Introduction: Augmented renal clearance (ARC) is common in trauma patients and associated with subtherapeutic antimicrobial concentrations. Early identification of patients with ARC is necessary to maximize antimicrobial doses and minimize treatment failure. The purpose of this study was to report the incidence of ARC, identify ARC risk factors and develop a predictive scoring model called ARCTIC (Augmented Renal Clearance in Trauma Intensive Care) that is specific to trauma patients.

Methods: Consecutive trauma patients who were admitted to the intensive care unit with a timed urine collection for measured creatinine clearance (CrCl) were considered for inclusion. Patients were excluded if their serum creatinine (SCr) was > 1.3 mg/dL. Identified patients were stratified based on the presence of ARC which was defined as a measured CrCl $\geq$ 130 ml/min. Demographics, comorbidities and trauma-specific variables (injury type, severity and mechanism) were then compared and multivariate analysis was performed. Using the results from the multivariate analysis, a weighted scoring system was constructed and evaluated using receiver operating characteristic (ROC) curve analysis. ARCTIC score cut-offs were determined based on sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV).

Results: There were 133 patients with a mean age of 48 ± 19 years and SCr of 0.8 ± 0.2 mg/dL. The most common injury type was head injury (48%) and 62% required mechanical ventilation. The mean measured CrCl was 168 ± 65 ml/min and the incidence of ARC was 67%. Multivariate analysis revealed the following risk factors for ARC [odds ratios (95% CI)]: age < 56 [58 (5.2 – 659)], age 56 to 75 [13.5 (1.2 – 152)], SCr < 0.7 mg/dL [15.2 (3 - 53)] and male gender [6.9 (1.9 – 25)]. Using these results, the ARCTIC scoring system was: 4 points if age < 56, 3 points if age 57 – 75, 3 points if SCr < 0.7 mg/dL and 2 points if male gender. ROC curve analysis revealed an area (95% CI) of 0.813 (0.735 – 0.892), p<.001. An ARCTIC score of ≥ 6 had a sensitivity, specificity, PPV and NPV of 0.843, 0.682, 0.842 and 0.682, respectively.

Conclusion: The incidence of ARC in trauma patients is high. The ARCTIC score represents a practical, pragmatic system that can be used at the bedside to predict ARC. An ARCTIC score $\geq$6 represents a good cut-off to screen for ARC where antimicrobial adjustments should be considered. Future studies are needed to determine the association between ARCTIC score and trauma patient management outcomes.

## THE FRAIL SCALE: A USEFUL TOOL FOR BEDSIDE SCREENING OF GERIATRIC TRAUMA PATIENTS

Cathy A. Maxwell Ph.D., Mary S. Dietrich Ph.D., Richard S. Miller* MD, Vanderbilt University Medical Center

Invited Discussant: Orlando Kirton, MD, MBA

Introduction: A 2013 consensus conference recommended routine screening for frailty by frontline clinicians. The validated FRAIL Questionnaire consists of 5 items derived from the Fried phenotype (4) and Rockwood deficit accumulation (1) models of frailty. Using data from our study on one-year geriatric trauma outcomes, we derived a 5-item FRAIL Scale score for 188 geriatric trauma patients to examine the influence of pre-injury physical frailty (as measured by FRAIL) on one-year outcomes. We hypothesized that FRAIL scores would predict function and mortality at 1-year post-injury.

Methods: Design: Secondary data analysis from a prospective cohort study. Participants: patients ≥ age 65 admitted through the ED between October 2013 and March 2014. Setting: Level I trauma center. Procedure: The five items of the FRAIL Scale instrument (**F**atigue, **R**esistance, **A**mbulation, **I**llnesses, **L**oss of weight) were generated. A pre-injury FRAIL score was created for each patient. Data analysis: Frequencies, measures of central tendency, linear and logistic regression.

Results: Mean age: 77.6 (SD 8.9), median injury severity score: 10 (IQR: 9-17), median comorbidity index: 3 (IQR: 0-9). Eighty-eight patients (47%) scored ≥ 2 on the AD8 dementia screen, indicating possible dementia. Among 188 admitted patients, 64 (34%) screened frail (FR AIL score ≥ 3), 71 (38%) screened pre-frail (score: 1-2) and 53 (29%) screened non-frail (score: 0). Frequencies (%) were derived for each component of the FRAIL scale: fatigue (N=123, 65%), ambulation (N=76, 40%),

FRAIL SCALE MEASURES AMONG GERIATRIC TRAUMA PATIENTS (N=188)
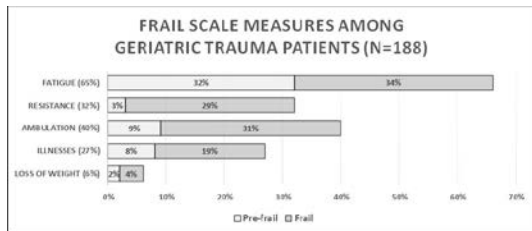
resistance (N=61, 32%), illnesses (N=51, 27%), loss of weight (n=11, 6%). One-year follow-up was completed on 176 (94%) patients for functional status (Barthel Index), and 184 patients (96%) for mortality. Multivariate regression: **Function:** Regression analysis revealed that after controlling for age, comordities, injury severity, and cognitive impairment (AD8), pre-injury FRAIL scores explained ~29% of the variability in physical function (β=-0.53, p<0.001) at 6-months post-injury. This association remained with function at one-year post-injury (N=129, β=-0.36, p<0.001). **Mortality (1-year):** 47 patients (26%) died within one year of admission. Logistic regression analysis revealed that after controlling for those same variables, the higher the pre-injury FRAIL score the greater the likelihood of mortality within one year (O.R.=1.74, p=0.001; CI: 1.27-2.39).

Conclusion: The 5-item FRAIL Questionnaire predicts functional status (as a measure of disability) and mortality at one-year among geriatric trauma patients. The FRAIL Scale is a useful tool for bedside frailty screening by clinicians. Incorporation of physical frailty measures into medical records and trauma registries will facilitate patient-centered care and provide a measure for risk adjustment with quality improvement efforts and research studies in trauma care settings.

APPLICATION OF EXOGENOUS PMN TO THE AIRWAY RESCUES BACTERIAL OVERGROWTH INITIATED BY TRAUMA DAMPS

Kiyoshi Itagaki Ph.D., Jing Zhang MD, Ingred Rica Ph.D., Dave Gallo BS, Leo E. Otterbein Ph.D., Beth Israel Deaconess Medical Center

Invited Discussant: Ronald Maier, MD

Introduction: Trauma is the leading cause of death in persons under 45. Nosocomial pneumonia is common in trauma patients so interventions to prevent and treat nosocomial pneumonia may improve outcomes. Our prior work strongly suggests that tissue injury
predisposes to nosocomial pneumonia because mitochondrial debris (MTD) originating from injured cells contains damage-associated molecular patterns (DAMPs). These reduce neutrophil (PMN) migration into the airway when bacterial inoculation occurs after injury. This suggested putting normal PMN into the airway might be beneficial.

Methods: All experiments were approved by the Institutional Animal Care and Use Committee. We randomly divided CD-1 mice into three experimental groups. **Group-1** got saline injected intra-peritoneal (*i.p.*) at T=-3h and bacteria (*S. aureus*, 1x106 CFU in 50 μL PBS) injected intra-tracheal (*i.t.*) at T=0. **Group-2** got MTD (isolated from 10% of a CD-1 mouse liver) *i.p.* at T=-3h and bacteria *i.t.* at T=0. **Group-3** got MTD *i.p.* at -3h, bacteria *i.t.* at T=0 and bone marrow (BM-)PMN (2x106 in 50 μL saline from CD-1 mice) *i.t.* at +3 h. Injection of bacteria and BM-PMN *i.t.* were performed using a catheter and holding mice vertically to allow passive, atraumatic delivery of the inoculum to the alveoli. Animals were sacrificed at +20h. Bacterial clearance was assayed first by culturing brochoalveolar lavage fluid (BALF, n>12/group) on agar plates with bacterial presence (CFU) in BAL and lung homogenates normalized to Group-1 values. We then repeated the experiments (n>13/group) culturing lung homogenates. Statistical analysis was done by one-way ANOVA. In preliminary experiments, PMN infusion *i.t.* had no untoward effects on recipient animals. Furthermore, infusion of PMN across strains (CD-1 vs. C57BL/6) also has no effect on the recipients.

Results: Results (mean ± SE) are shown in the figures below. Our initial determinations of bacterial clearance used BALF. Here we found that, as expected, MTD given *i.p.* decreases lung clearance of bacteria. But remarkably, exogenous BM-PMN given *i.t.* 3 hours after bacterial inoculation returned clearance to normal levels (*p=0.002) (Figure 1). Experiments using lung homogenates showed a similar trend (P=0.027; saline vs. MTD, p=0.015; MTD vs. MTD+PMN) (Figure 2) with experiments still ongoing.
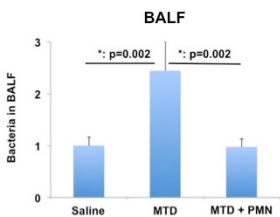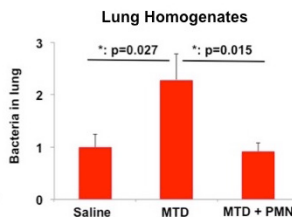
Bacterial Clearance

Figure 1.

Figure 2.

Conclusion: These data further support that mitochondrial DAMPs can cause PMN redistribution toward injured sites. Thus fewer PMN may reach the inoculated lung, reducing bacterial clearance. This model may mimic clinical conditions where PMN migrate towards injured sites limiting the number of PMN available to clear pneumonia. Moreover, instillation of normal PMN into the trachea clearly rescued the suppression of bacterial clearance cause by mitochondrial DAMPs using the BALF model. Preliminary experiments using lung homogenate methods also support that finding. Moreover, intra-tracheal PMN infusion did not cause adverse effects. Thus intra-tracheal PMN instillation is worthy of study as a potential adjunctive therapy aimed at decreasing the morbidity of bacterial lung infections in trauma patients.

PARENTERAL AND ENTERAL NUTRITION HAVE DIVERGENT EFFECTS ON RIBONUCLEOTIDE SYNTHESIS, NITROGEN AND KREBS CYCLE METABOLISM AFTER TRAUMATIC INJURY

Brodie Parent MD, Max Seaton MD, Danijel Djukovic Ph.D., Brittany Wheelock Lauren Jacobson Daniel Raftery Ph.D., Grant E. O'Keefe* MD,MPH, University of Washington
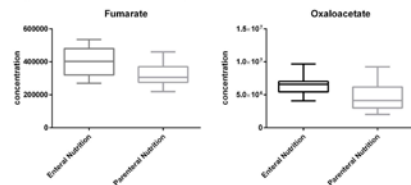
Invited Discussant: Panna Codner, MD

Introduction: Artificial nutritional support is important in the care of critically ill trauma patients. While the enteral (EN) route is preferred, there are circumstances when parenteral nutrition (PN) is considered necessary. EN is associated with fewer nosocomial infections and lower overall morbidity than PN. However, potential biologic mechanisms for differences are not clear. We sought to better understand how EN and PN influence metabolic pathways in critically ill trauma victims using system-wide metabolomics. We hypothesized that metabolic responses to the institution of enteral and parenteral nutrition would be different in ways that might help us understand how to optimize their use.

Methods: We enrolled subjects prospectively over 7 months in 2015 at an urban, level-one trauma center. Subjects were included if they were started on either enteral nutrition (EN) or parenteral nutrition (PN) during their inpatient admission and consented to participate. Plasma samples were obtained between 1-12 hours prior to starting artificial nutrition, and 3 and 7 days later. All samples were stored at -80 Celsius, and then analyzed with liquid chromatography and mass spectrometry. We assessed differences in plasma metabolite concentrations and used principle component analyses and multiple linear regression to select biomarkers of interest.

Figure 1. Plasma concentrations of Krebs cycle intermediates in critically-injured subjects on enteral nutrition versus parenteral nutrition.

Results: 20 subjects were enrolled (10 EN and 10 PN) and sampled over 7 days. The median age was 41 and the median ISS was 30. There were no differences in baseline characteristics between the two groups, except for relatively more blunt-trauma mechanisms in the EN group. A total of 60 plasma samples were collected and 112 metabolites per sample were analyzed. Relative to EN subjects, PN subjects showed an impaired Krebs cycle metabolism (decreased fumarate and oxaloacetate, $p<0.05$, Figure 1) and decreased nitrogen turnover (decreased urea cycle intermediates: citrulline, ornithine and urea, $p<0.05$). Finally, EN subjects showed increasing ribonucleic acid (RNA) synthesis over time (increased uridine, cysteine and oxypurinol, $p<0.05$), but this was not observed in PN subjects.

Conclusion: Metabolic differences between enteral and parenteral therapy are evident. EN is associated with amino-acid anabolism and increasing RNA synthesis over time. However, PN is associated with impairments in RNA synthesis, Krebs cycling and nitrogen metabolism. These data suggest that PN contributes to less effective energy metabolism and delayed protein synthesis. Our data support the notion that parenteral nutrients are utilized less effectively than enteral nutrients. Biomarkers reported in this study can be rapidly obtained and may be useful in guiding both enteral and parenteral nutritional therapy in critically ill patients.

EVALUATION OF GUIDELINES FOR INJURED CHILDREN AT HIGH RISK FOR VTE: A PROSPECTIVE OBSERVATIONAL STUDY

Rachel Landisch MD, Laura Cassidy Ph.D.,RN, Kristin Braun RN, Rowena Punzalan MD, Sheila Hanson MD, David Gourlay* MD, Children's Hospital of Wisconsin

Invited Discussant: Elliott Haut, MD, PhD

Introduction: Venous thromboembolism (VTE) pharmacologic prophylaxis is a widely accepted practice in adult trauma patients to prevent associated morbidity. However, VTE prophylaxis has not been standardized in injured pediatric patients. Our institution identified factors potentially associated with a high risk of VTE in critically injured pediatric patients that led to the development and implementation of a VTE prophylaxis guideline.

Methods: Data were prospectively collected on injured children from 8/2010-8/2015. Pharmacologic prophylaxis was indicated for patients identified by the guidelines as high risk for VTE. Prophylaxis was deferred and a screening ultrasound (US) performed if the high risk VTE patients were also at high risk for bleeding. To assess the accuracy of predicting confirmed cases of VTE, stepwise logistic regression analysis was used to measure the association of individual risk factors with VTE controlling for age (≥ 13 years). A receiver operating characteristic (ROC) curve measured the accuracy of the final model to predict a VTE.

Results: Of 4092 trauma patients, 588 were admitted to the ICU of which the guidelines identified 199 as high risk. VTE occurred in 4% (23/588) of the ICU population and 10% (20/199) of the high risk. The median age of VTE patients in the ICU was 9.7 years. The statistically significant predictors ($p<0.05$) of VTE in the multivariate model included presence of a central venous catheter (OR=5.2), inotropes (OR=7.7), immobilization (OR=5.5) and a Glasgow Coma Scale (GCS) < 9 (OR=1.3). The area under ROC curve of this model was 0.92, demonstrating its excellent predictive ability.

Conclusion: The results demonstrate that critically injured pediatric patients are at high risk for VTE. The analysis established a subset of factors that significantly increase the risk of a VTE. Identification of these risk factors should be incorporated into standardized protocols for earlier detection and prevention.

Figure 1. ROC analysis to predict VTE based on age, central venous catheter, inotropes, immobilization, and GCS.
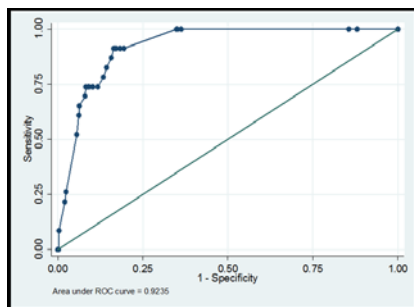
TROJAN HORSE OUT OF BARN: TRAUMA PATIENTS' CELL FREE SERA CONTAINS FUNCTIONAL MITOCHONDRIA INDICATING POOR OUTCOME

Eszter Tuboly Ph.D., Daniel McIlroy BS,MD, MRCS (eng.), Natalie Lott RN, Gabrielle Briggs Ph.D., Zsolt J. Balogh* MD,Ph.D., John Hunter Hospital, University of Newcastle

Invited Discussant: James Hoth, MD

Introduction: Cell free mitochondrial DNA (mtDNA) is a potent driver of postinjury inflammation and suggested as a marker of poor outcome. The cellular origin and the mechanism of mtDNA release is largely unknown. We hypothesized that trauma patients' sera contains cell free mitochondria as potential stage in the mechanism of mtDNA release.

Methods: Prospective cohort study was performed on 70 patients (72% male, Age:41 ± 17; ISS:19 ± 13; BD:0.2 ± 3) requiring major orthopaedic trauma surgery and 18 healthy controls (Age:36 ± 7). De-cellularized plasma was investigated for cell free mitochondria with flow cytometry (Mitotracker Deep Red; count/μL), mtDNA concentration was quantified by RT-PCR (ng/mL). Spectrophotometry was used to determine the cytochrome-c oxidase (CCOX) activity of the acellular plasma (U/min/μg/ml protein). The outcomes were SIRS, MOF and Sepsis (complicated outcome, CO).

Results:15 patients developed CO and their demographics, injury and shock severity was comparable to the 55 no-CO patients. Trauma patients' sera contained significantly more cell free mitochondria (p< 0.001) than controls. Controls had significantly lower CCOX activity (p<0.001) than trauma patients. CO patientshad significantly higher CCOX activi ty than non-CO patients (p< 0.05) but no difference was detected in their mtDNA concentration (p= 0.5340).There was no correlation between the extracellular CCOX activity and ISS or BD. There was a negative correlation (r= -0.327, p< 0.05) between the extracellular CCOX activity and mtDNA concentrations in trauma samples.

Conclusion:We discovered that trauma patients have large number of functional cell free mitochondria in their sera, which could be the source of the proinflammatory cell free mtDNA. Increased preoperative cell free mitochondrial CCOX activity is associated with poor outcome in patients with similar age, injury and shock severity.
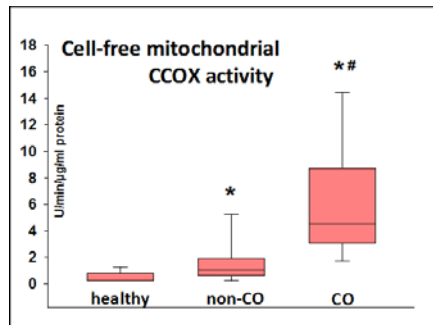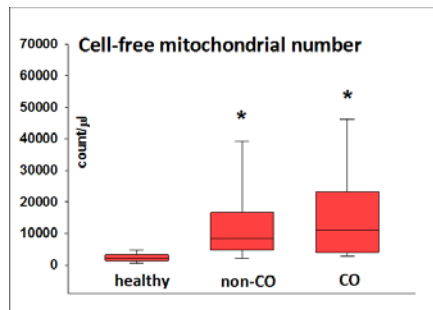
IMPACT OF INCLUDING HIGHEST GCS MOTOR SCORE IN THE RISK-ADJUSTMENT OF TRAUMATIC BRAIN INJURY MORTALITY

David Gomez MD,Ph.D., James Byrne MD, Wei Xiong Ph.D., Aziz Alali MD, Ph.D., Haris Subacius Ph.D., Christopher Hoeft Avery B. Nathens* MD, MPH, Ph.D., University of Toronto, Department of Surgery

Invited Discussant: Adil Haider, MD, MPH

Introduction: The Glasgow Coma Scale (GCS) is the most widely accepted and utilized measure of traumatic brain injury (TBI) severity. Traditionally, the first GCS score is used to assess baseline risk and to define severe TBI. However, the GCS wasn't only designed to assess patients at one point in time, but rather to identify and quantify changes in neurological status over time. We postulated that the post-resuscitation GCS, or highest GCS in the first 24 hours, might be a better predictor of death. Our objective was to evaluate the impact of including the highest GCS score in risk-adjustment models for the purpose of trauma center performance benchmarking.

Methods: Data were derived from the American College of Surgeons Trauma Quality Improvement (TQIP) analytic dataset (Jan 2014 – March 2015). We focused our analysis on the isolated severe TBI cohort which included patients =>16 years, with head Abbreviated Injury Scale (AIS) scores => 3, total GCS =<8, and AIS scores =< 2 in all other body regions. We used only the motor component (mGCS) to avoid confounding with endotracheal intubation. Only centers reporting both initial and highest mGCS were included. Different risk-adjustment models, which included a different combination of initial and highest mGCS scores as covariates as well as additional patient and injury characteristics, were created. Model performance and fit were then evaluated across all models. In addition, the external benchmarking results (i.e. change in center outlier status, change in decile, and Odds Ratio change >0.5 standard deviation) of all models was compared to a reference model using initial mGCS only.

Results: 6,768 patients across 232 centers met severe TBI cohort criteria and had available highest mGCS. Initial and highest mGCS scores were different in 49% of patients; with highest mGCS scores being lower in 1.2% and higher in 47.8% of patients. Model performance was optimal when both initial and highest mGCS were included in the model as evidenced by C-index, HL p value, AIC, and adjusted R2. When both were included as covariates, ten centers changed outlier status compared to a reference model using initial mGCS only. In addition, almost half of centers (46.6%, n=108) exhibited a significant change in their risk-adjusted odds ratio of death when both initial and highest mGCS were included as covariates compared to using initial mGCS only.

Inclusion of mGCS across models	Change in outlier status	Change in decile	Odds ratio change >0.5 SD
Initial mGCS only	reference	reference	reference
Highest mGCS only	9 (3.9%)	180 (77.6%)	107 (46.1%)
Initial and Highest mGCS	10 (4.3%)	177 (76.3%)	108 (46.6%)

Conclusions: The inclusion of highest mGCS score in risk-adjustment models of severe traumatic brain injury leads to improved model performance and potentially meaningful changes in risk-adjusted performance ranking of centers.