

Contemporary Management and Outcomes of Blunt Thoracic Aortic Injury: A multicenter retrospective study

Joseph J. DuBose* MD, Sam Leake BS, Megan Brenner MD, Tom Scalea* MD, Jason Pasley MD, Thomas O'Callaghan MD, Xian Luo-Owen MD, Ph.D., Marc D. Trust MD, Jennifer Mooney MD, Herb Phalen* MD, Omar Rivera MD, Kenji Inaba* MD, Martin Zielinski* MD, Gary Vercrusse* MD, Ali Azizzadeh MD, University of Texas Health Science Center-Houston

Invited Discussant: Michael Sise, MD

Introduction: Blunt thoracic aortic injuries (BTAI) comprise a spectrum from intimal tear to rupture; yet optimal management and ultimate outcome has not been clearly established.

Methods: Retrospective multicenter study of BTAI from Jan 2008 to Dec 2013. Demographics, diagnosis, treatment and in-hospital outcomes were analyzed.

Results: Nine ACS Level I trauma centers contributed data from 453 patients with BTAI. After exclusion of patients expiring prior to imaging (58), and transfers (13), 382 patients with imaging diagnosis were available for analysis (SVS Grade 1 = 94, Grade 2 = 68, Grade 3 = 192, Grade 4 = 28). Hypotension (SBP < 90 mm Hg) was present on admission in 56 (14.7%). CTA alone was utilized for diagnosis in 94.5% of patients. Non-operative management (NOM) was selected in 32%, with only 2 in-hospital failures (Grade 1, Grade 4) requiring endovascular (TEVAR) salvage. Open repair (OR) was successfully completed in 61 (16%). TEVAR was conducted in 198 (52%) at a mean of 3.1 days after injury; with 41% of these undergoing left SCA coverage. Complications following TEVAR included endograft malposition (6, 3.0%) endoleak (5, 2.5%), paralysis (1, 0.5%) and stroke (2, 1.0%). Six TEVAR failures were treated by repeat TEVAR (2) or OR (4). Overall in-hospital mortality was 18.8% (NOM 34.4%, OR 19.7%, TEVAR 8.6%), with an aortic-related mortality of 6.5% (NOM 9.8%, OR 13.1%, TEVAR 2.5%) [Grade 1 = 0%, Grade 2 = 2.9%, Grade 3 = 5.2%, Grade 4 = 46.4%]. The majority of aortic-related deaths (18/25) occurred prior to the opportunity for repair. Independent predictors of aortic-related mortality among all BTAI patients were advanced chest AIS, greater SVS Grade and greater ISS; with TEVAR proving protective ($p = 0.03$, OR 0.25 [0.07-0.87]).

Conclusions: Based on in-hospital outcomes, failures and aortic-related mortality of NOM following BTAI SVS Grade –1-3 injuries are rare. Early complications of TEVAR have substantially decreased relative to prior reports. Prospective long-term follow-up data is required to better refine indications for intervention following BTAI.

EARLY WHOLE BLOOD AUTO-TRANSFUSION: AN UNDEFINED PRACTICE IN CIVILIAN TRAUMA

Bellal Joseph* MD, Kenji Inaba* MD, Viraj Pandit MD, Stefano Siboni MD, Gary Vercruysse* MD, Narong Kulvatunyou* MD, Andrew Tang MD, Terence O'Keeffe* MD, MBChB, Donald J. Green* MD, Lynn Gries MD, Randall S. Friesse* MD, Demetrios Demetriades* MD, Peter Rhee* MD, MPH, University of Arizona - Tucson

Invited Discussant: Juan Duchesne, MD

Introduction: The changing transfusion practices advocate early and liberal use of blood products for resuscitation in trauma patients. However; the use of whole blood resuscitation in civilian trauma practice remains a rare phenomenon. The aim of this study was to assess outcomes in trauma patients receiving whole blood auto-transfusion (AT).

Methods: This 6 year multi-institutional retrospective study included all trauma patients requiring transfusions on presentation in the emergency department. Patients that received AT were matched to patients that did not receive AT (No-AT) using propensity score matching in a 1:1 ratio for demographics, injury severity score (ISS), systolic blood pressure (SBP), and international normalized ratio (INR). AT was defined as transfusion of blood from patient's chest and/or abdominal cavity. Outcome measures were: in-hospital complications and mortality. In-hospital complications were defined as acute respiratory distress syndrome (ARDS), sepsis, disseminated intravascular coagulation (DIC), renal insufficiency, and transfusion related acute lung injury (TRALI).

Results: A total of 272 patients (AT: 136, No-AT: 136) were included. There was no difference in age ($p=0.81$), injury severity ($p=0.56$), head AIS ($p=0.42$), SBP ($p=0.48$), and INR ($p=0.21$) between the two groups. AT was initiated in the emergency department (ED) in 48.5% patients while remaining ($n=70$) received AT in both ED and operating room.

Table 1: Outcomes			
Variables	AT (n=136)	No-AT (n=136)	<i>p</i>
PRBC	10.3±7.3	12.1±9.7	0.03
Platelets	5.2±4.2	7.9±5.4	0.04
FFP	6.1±3.9	8.2±6.5	0.24
24 post admission INR	1.3±1.1	1.1±1	0.31
In-hospital Complications	12.5%	10.3%	0.61
Mortality	18.3%	15.4%	0.51
Cost of Therapy	8,794±6,531	10,427±8,621	0.03
Hospital Cost	42,156±40,981	43,963±40,528	0.04

Conclusion: Early whole blood AT is a safe and effective practice in severely injured trauma patients. Auto-transfusion resulted in lower packed red blood cell and platelet transfusions as well as lower costs without increasing complications or mortality.

DEFINING THE EXCESS MORBIDITY AND MORTALITY ATTRIBUTABLE TO EMERGENCY GENERAL SURGERY

Allan B. Peetz MD, Ali Salim* MD, Zara Cooper MD, Edward Kelly* MD, Reza Askari MD, Jonathan Gates MBA,MD, Gally Reznor MS, Joaquim Havens MD, Brigham and Womens Hospital

Invited Discussant: Shahid Shafi, MD

Introduction: Emergency general surgery (EGS) carries a disproportionate burden of risk from medical errors, complications and death compared to non-emergency general surgery (NEGS). Previous studies have been limited by patient and procedure heterogeneity, but suggest worse outcome due to preoperative risk factors. We hypothesize that the disproportionate morbidity and mortality in EGS patients are not fully explained by these factors but are due to the EGS itself.

Methods: We retrospectively analyzed data from patients in the American College of Surgery National Surgical Quality Improvement Program (ACS-NSQIP) database that underwent one of 14 selected procedures between 2008 and 2013. The procedures represented general and vascular surgery operations common to both emergency and elective settings including; visceral resection, abdominal wall hernia repair, ileo-mesenteric bypass, and aortic reconstruction. Patients were stratified based on emergency status. The primary outcome was death within 30 days of operation. Secondary outcomes included post-operative complications. 42 preoperative variables were analyzed from the ACS-NSQIP preoperative risk assessment which includes demographic data, functional and dependent status, smoking and alcohol history, comorbidities, presence of sepsis, acute renal failure, revascularization/amputation, recent dialysis, impaired sensorium, pneumonia, recent ventilator dependence, steroid use, bleeding disorders, preoperative blood transfusions, laboratory data, and American Society of Anesthesia classification. Additionally, wound class and 23 post-operative outcomes were analyzed. This included the ACS-NSQIP post-operative occurrences (wound, respiratory, urinary tract, central nervous system, cardiac, hematologic, and septic). A Chi-square test was used to compare categorical variables and the Wilcoxon rank sum test for continuous variables. Multivariate logistic regression analysis was performed to identify independent risk factors for mortality and complications.

Results: Of 66,665 patients, 24,068 underwent emergency procedures and 42,597 were non emergent. Death occurred in 12.5% of EGS patients and 2.7% of NEGS patients ($p<.0001$). Post-operative complications occurred in 48.2% of EGS patients and 27.5% of NEGS patients ($p<.0001$). When preoperative risk factors, type of procedure, and post-operative complications were controlled, EGS was independently associated with death (Odds Ratio (OR) 1.13 $p<.0001$) and complications (OR 1.09 $p<.0001$). EGS was also independently associated with wound (OR 1.03 $p=0.07$) and respiratory complications (OR 1.17 $p<.0001$).

Conclusion: EGS is an independent risk factor for death and post-operative complication. The disproportionate morbidity and mortality observed in EGS is independent of patient factors, type of operation, and type of post-operative complication. Research seeking to improve EGS patient outcomes should include investigating the cause of this excess burden of risk with special consideration for identifying modifiable factors.

INDUCING ACUTE TRAUMATIC COAGULOPATHY IN VITRO

Benjamin M. Howard MD,MPH, Lucy Z. Kornblith MD, Christopher K. Cheung BA, Matthew E. Kutcher MD, Ryan F. Vilardi MS, Byron Miyazawa BS, Mitchell J. Cohen* MD, San Francisco General Hospital; University Of California, San Francisco

Invited Discussant: Walter Biffl, MD

Introduction: Nearly one third of critically injured patients present with acute traumatic coagulopathy, independent of iatrogenic causes. This coagulopathy has been associated with shock and tissue injury, and may be mediated via activation of the protein C pathway. Patients with acute traumatic coagulopathy have prolonged PT and PTT, and decreased activity of factors V and VIII; they are also hypocoagulable by thromboelastometry (ROTEM) and other viscoelastic assays. To test the etiology of this phenomenon, we hypothesized that such coagulopathy could be induced *in vitro* in healthy human blood with the addition of activated protein C (APC).

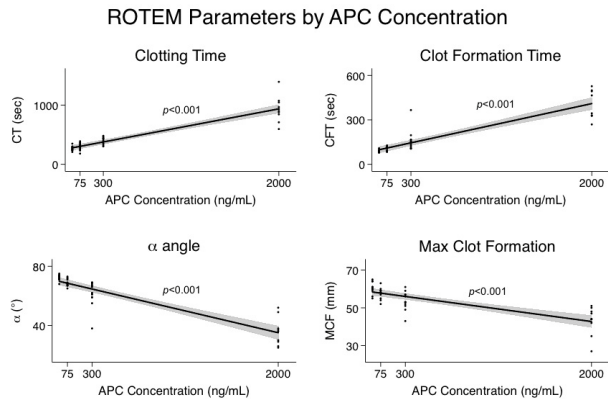
Methods: Whole blood was collected from ten healthy human subjects, and was “spiked” with increasing concentrations of purified human APC (control, 75, 300, 2000 ng/mL). PT/PTT, factor activity assays, and ROTEM were performed on each sample. Statistical differences were assessed across and between APC concentration groups, and linear regression was performed to assess the association of APC concentration with PT/PTT, factor activity, and ROTEM parameters.

Results: In all subjects, increasing concentrations of APC produced ROTEM tracings consistent with traumatic coagulopathy. ROTEM EXTEM parameters differed significantly by APC concentration, with stepwise prolongation of clotting time (CT) and clot formation time (CFT), decreased alpha angle (α), and reduced maximum clot

firmness (MCF). Significant prolongation of PT and PTT and decreased activity of factors V and VIII were observed at higher APC concentrations. Linear regression demonstrated that for every 100 ng/mL increase in APC concentration, CT prolonged by 32.9 seconds, CFT prolonged by 22.2 seconds, α decreased by 1.7 degrees, and MCF

decreased by 0.8 mm (all $p < 0.001$; see Figure); PTT was prolonged by 2.1 seconds, factor V activity decreased by 1%, and factor VIII activity decreased by 2.7% (all $p < 0.01$).

Conclusion: In this study, we reproduced a phenotype of acute traumatic coagulopathy in healthy blood by the *in vitro* addition of APC alone, as evidenced by viscoelastic measures and confirmed by conventional coagulation assays and factor activity. This lends further mechanistic insight to the etiology of coagulation abnormalities in trauma, supporting the central role of the protein C pathway. Our findings also represent a novel model for future investigations in the diagnosis and treatment of traumatic coagulopathy.



INHALED, NEBULIZED SODIUM NITRITE PROTECTS AGAINST TRAUMA/HEMORRHAGIC SHOCK INDUCED TISSUE INJURY AND INFLAMMATION

Benjamin Kautza MD, Daniel Escobar MD, Ana Botero MD, Hakon Haugaa MD, Michael Pinsky MD, Sruti Shiva Ph.D., Hernando Gomez MD, Andrew Peitzman* MD, Brian Zukerbraun MD, University of Pittsburgh

Invited Discussant: Rosemary Kozar, MD, PhD

Introduction:

Trauma and hemorrhage results in tissue injury and inflammation that contributes to morbidity and mortality. Organ injury from trauma and hemorrhage occurs in part from the development of cellular shock and oxidative injury. Endogenous adaptive responses to tissue hypoxia are helping to guide the development of resuscitative adjuncts to limit tissue injury, including investigations into nitrite/nitrite reductase/nitric oxide signaling pathway. The purpose of these investigations was to test the hypothesis that inhaled, nebulized sodium nitrite protects against the development of shock and tissue injury in models of trauma and hemorrhagic shock.

Methods:

Male C57BL/6 mice were randomized to sham surgery or soft tissue injury+hemorrhage to 25mmHg for 2 hours followed by resuscitation with lactated ringers (2X volume of shed blood). In each group, some mice were further treated with inhaled nebulized sodium nitrite (NaNO_2 ; 30 mg in 5ml into environment over 20 minutes) or vehicle at the time of resuscitation. Mice were sacrificed 4 hours after resuscitation. Yorkshire Durock pigs (30-35kg) underwent vascular cannulation and were randomized to anesthesia only or hemorrhage to 30mmHg and bled to maintain a pressure between 30-40 for 90 minutes. Shocked pigs were randomized to receive vehicle or inhaled nebulized NaNO_2 211mg in 2.5 mL PBS. Pigs were sacrificed 4 hours after resuscitation. Hemodynamics, blood, and microdialysis specimens were collected throughout.

Results:

In a murine model, trauma/hemorrhage resulted in organ injury and inflammation as demonstrated by increased serum ALT, Cystatin C and IL-6. Nebulized nitrite limited these responses ($P < 0.05$). Additionally, nitrite limited oxidant injury as determined by lipid peroxidation. In a porcine model of hemorrhagic shock, nebulized nitrite was associated with significant decreases in blood, muscle, and peritoneal fluid lactate concentrations ($P < 0.05$), and significant decreases in glycerol release into peritoneal fluid ($P < 0.05$). Additionally hemorrhage resulted in mitochondrial injury as determined by decreased respiratory control ratio in both muscle and platelets. Nitrite prevented this injury. Furthermore, hemorrhage induced platelet activation was limited by nitrite.

Conclusion:

Resuscitation adjuncts to limit the development of shock, oxidant stress, and thus tissue injury hold the promise of improving outcomes. Nebulized NaNO_2 was a protective resuscitative adjunct in both murine and porcine models of hemorrhagic shock and resuscitation, and may prove useful in human trauma and hemorrhage, however further investigations are warranted.

TWO YEAR CESSATION OF RESIDENT TEAMWORK TRAINING IMPACTS TRAUMA RESUSCITATION PERFORMANCE AND EFFICIENCY

Charles T. Harris MD, Ellen Harvey RN, DNP, Andrea Wright RN, MSN, Dallas Taylor BS, RN, Carol Gilbert* MD, Bryan Collier* DO, Carilion Roanoke Memorial Hospital

Invited Discussant: Joseph Galante, MD

Introduction: Prior studies suggest structured teamwork training improves trauma team resuscitation performance and outcomes. This study examines the impact of *cessation* of resident training as a component of a multidisciplinary TeamSTEPPS simulation-based training program on previous performance gains noted in the trauma resuscitation setting.

Methods: This prospective, observational follow-up study of trauma team resuscitation performance was conducted in a Level 1 trauma center. Trained evaluators scored team performance during trauma resuscitations using the validated Trauma Team Performance Observation Tool (TPOT). Possible scores ranged 21 to 105. Efficiency (minutes) data were gathered from the trauma registry for ED dwell time, time to FAST, and time to CT scan during the same time period TPOT scores were collected. Data collected two years after cessation of training were compared to pre-training, post training, and one year post ongoing training periods. For each outcome variable, the data were rank-transformed and analyzed using the analysis of variance. If a significant overall group effect was detected ($p < 0.05$), a Dunnett's Multiple Range Test was performed.

Results: TPOT scores increased significantly from pre-training ($N=33$) to post training ($N=40$) (62.2 to 74.7, $p<.0001$) and sustained one year later ($N=32$) (72.5, $p<.0001$) with ongoing training. TPOT scores at 2 years cessation ($N=43$) declined close to pre-training levels (66.6, $p=.0735$) and were significantly lower than the scores at post training and one year post ongoing training ($p<0.05$). A decline in efficiency in minutes (post training vs. 2 year post cessation) was also noted in ED dwell time (190 vs. 323; $p<0.0001$), time to FAST (10.11 vs. 14.03; $p<0.0001$), and time to CT scan (26.5 vs. 29.2; $p=.0008$).

Conclusion: A 2 year cessation of resident teamwork training is associated with deterioration of trauma team performance scores, increased times to critical radiologic trauma exams (FAST and CT), and overall prolonged ED dwell times placing trauma patient outcomes at risk.

OPERATIVE VERSUS NON-OPERATIVE MANAGEMENT OF MULTIPLE RIB FRACTURES

Mauricio Velasquez MD, Carlos Ordonez* MD, Michael Parra* MD, Andres Dominguez MD, Juan C. Puyana* MD, Fundacion Valle Del Lili

Invited Discussant: Marc de Moya, MD

Introduction: Multiple ribs fractures (MRF) are associated with high rates of morbidity and mortality. Our goal was to compare outcomes between the traditional non-operative management and that of a comprehensive surgical approach.

	Control group	Operative group	p_value
n	20	20	
Age, *	44.5 (36-54.5)	51.1 (41-63)	0,2153
Número of fractured ribs*	5 (4-6.5)	5 (4-8)	0,065
Ventilator days*	10 (6-16)	2 (1-3)	0,000
ICULOS*	8 (6-10.5)	4.5 (1-8)	0,0199
HLOS*	16 (11-22)	6 (4-10)	0,0001
Respiratory morbidity, n(%)	13 (65)	5 (16.7)	0,000
CTLOS*	9 (7-12)	3 (2-5.5)	0,000
ISS*	13 (9-17)	9 (9-16)	0,357
CHEST AIS	3	3	
Mortality,n(%)	2 (10)	0 (0)	0,155
* Median (IQR)			

Methods: Retrospective analysis of adult MRF injuries from June 2011 to December 2013 at a regional level I trauma center. Patients with concurrent severe closed head injuries (Glasgow Coma Score <8) were excluded. Data was collected prospectively in the operative group and was compared to a historic non-operative control group matched for age, ISS and number of ribs fractured from the same institution. Outcome variables included were duration of mechanical ventilation (DMV), intensive care unit length of stay (ICULOS), hospital length of stay (HLOS), chest tube length of stay (CTLOS), incidence of pneumonia and mortality. Surgical stabilization of the rib fractures was performed with the Strasbourg Thoracic Osteosyntheses System (STRATOS [MedXpert GmbH, Heitersheim, Germany]). This system consists of titanium screw less clips which facilitates a less invasive surgical fixation and stabilization of the rib fractures.

Results: MRF were identified in a total of 40 patients and evenly divided among both groups. The operative group demonstrated a significant reduction in DMV (median of 10 (6-16) vs. 2 (1-3) [p<0,000]), ICULOS (median of 8 (6-10,5) vs. 4,5 (1-8) [p<0,0199]), HLOS (median of 16 (11-22) vs. 6 (4-10) [p<0,0001]), CTLOS (median of 9 (7-12) vs. 3 (2-5,5) [p<0,000]), pneumonia rates (65% vs. 16.7% [p<0,000]), and overall mortality (2 vs. 0). Death was due to pulmonary sepsis in one case and ARDS in the other

Conclusion: As compared with non-operative therapy, operative fixation of MRF is associated with reductions in DMV, HLOS, CTLOS and overall pneumonia rates.;

A COMPARISON OF DIAGNOSTIC PERITONEAL LAVAGE TO COMPUTED TOMOGRAPHY IN THE DIAGNOSIS OF THORACO-ABDOMINAL STAB WOUNDS

Reza Salabat MD, Andrew Dennis DO, John Kubasiak MD, Adelaide Kaczynski BS, Samuel Kingsley MD, Elizabeth Gwinn MD, Kimberly Joseph* MD, Frederic Starr MD, Dorion Wiley MD, Faran Bokhari MD, Kimberly Nagy* MD, Cook County Hospital

Invited Discussant: Leonard Weireter, Jr., MD

Introduction: Studies have reported 27% occult diaphragmatic injury due to stab wounds (SW) to the thoraco-abdomen (TA), with nearly 36% mortality if found incarcerated. The computed tomography (CT) is a widely used initial diagnostic tool, but it lacks the sensitivity to detect diaphragm injuries. We assessed the application of diagnostic peritoneal lavage (DPL) in determining missed abdominal and/or diaphragmatic injuries by CT and the ability to predict a therapeutic laparotomy in patients with SW to TA region.

Methods: Data was collected prospectively from 2006 to 2011. Inclusion criteria consisted of hemodynamic stability and patients who underwent both CT and DPL. Patients were excluded if they were hemodynamically unstable, had evisceration or peritonitis, or had only one of the above tests. A positive DPL was defined as RBCs > 10,000/mm³. A positive CT was defined as free air, intra-abdominal organ injury/laceration or hematoma adjacent to an organ. Sensitivity (SN), specificity (SP) were calculated independently for DPL and CT. A therapeutic exploratory laparotomy was defined as presence of an injury, which required intervention.

Results: During the study period, there were 192 patients with SW to TA of which 58 met our criteria. DPL resulted in 12 true positive (TP), 0 false positive (FP), 1 false negative (FN) and 45 true negative (TN) results for detection of injury, whereas CT scan was shown to have 7 TP, 0 FP, 6 FN, and 45 TN tests. Sensitivity (SN) was demonstrated to be 92% vs. 53% for DPL vs. CT, respectively. Specificity was 100% for both groups. When only therapeutic laparotomy was considered, we found 12 TP, 0 FP, 0 FN, and 45 TN DPL results, compared to CT scan which had 6 TP, 0 FP, 6 FN, and 45 TN tests. Sensitivity was demonstrated to be 100 vs. 50% for DPL vs. CT, respectively. Specificity was 100% for both groups. Notably, CT missed 1 colon, 2 splenic, 3 hepatic, and 7 diaphragmatic injuries. Four of the diaphragmatic injuries were found on the left anterior and lateral aspects

Conclusion: DPL was found to be superior to CT both for detection of intra-abdominal organ injury and for prediction of therapeutic exploratory laparotomy. CT missed all diaphragmatic injuries as well as 6 other intra-abdominal injuries. We conclude that CT, despite improvements in technology, remains a poor test for evaluating the diaphragm after penetrating TA trauma. When attempting to rule out potentially operative injuries to the diaphragm, DPL continues to be a useful test that should remain in the arsenal of every trauma surgeon.

THE IMPACT OF IMAGE-SHARING ON THE EVALUATION OF TRAUMA TRANSFER PATIENTS IN A RURAL TRAUMA SYSTEM

Tanveer Zamani MD, FRCSI, Chris Wargo MSN, James Dove BA, Jeffery L. Wild MD, Kenneth A. Widom MD, DiAnne Leonard* MD, FACS, Susan M. Baro DO, Aalpen Patel MD, Kim L. Roadarmel Geisinger Health System

Invited Discussant: Sharon Henry, MD

Introduction: Many rural trauma centers receive patients that are first evaluated at local hospitals (LH). LH transferring patients to regional trauma centers (TC) often obtain computed tomography (CT) scans to diagnose injuries and justify transfer. Many studies have shown that these studies are often repeated for a variety of reasons, including inadequate technique of acquisition of images and software incompatibilities. Repeating these studies adds a tremendous cost and radiation exposure to trauma patients. This study was performed to determine how the implementation of image-sharing systems impacted the rate of repeat CT scans during interfacility transfers at a rural Level I trauma center.

Methods: All trauma alert patients age greater than 15 years, transferred with prior CT imaging to a rural Level I trauma center from January 1, 2009 until December 31, 2012 were retrospectively reviewed. Data abstracted included CT scans performed at LH and CT scans repeated at the TC. The data was further divided into three time periods: pre-image sharing implementation (2009), peri-implementation (2010-2011), and post-implementation (2012). We compared the incidence of repeat CT scans with the implementation of image sharing system during these periods by using Cochran-Armitage trend test. We used Head CT (HCT) as a model study tool to review the impact of imaging on the cost and radiation exposure.

Results: During the study period, 1259 patients were transferred to the Level I TC. Of the total study population, 1003 (79.6%) patients underwent CT imaging prior to transfer. During this 4-year period, 554 (55.2%) patients underwent repeat CT imaging. When compared to the pre-implementation period, where 126/180 (70%) patients with prior imaging had CT scans repeated and 209/439 (47.6%) pre-transfer CT scans were repeated, in the post-implementation period, the number of patients with prior imaging who had repeat CT scans was decreased to 131/294 (44.6%) and only 201/751 (26.8%) pre-transfer CT scans were repeated which has p value of <.001. This saved \$784,531.00 in 2012, as compared to \$335,397.00 in 2009. Focusing on HCT, in the pre-implementation period, 142 out of 180 patients with pre-transfer imaging had HCT available, out of which 82/142 (57.7%) patients had HCT repeated, 60/142 (42.2%) had no repeat HCT; saving \$70,020.00 and preventing patients from further radiation exposure with the saving of total 4,392 mGy of radiation dose. In the post-implementation period, 228 out of 294 patients with prior imaging on transfer had HCT performed, out of which only 69/228 (30.3%) patients had HCT repeated while 159/228 (69.7%) did not have HCT repeated. This saved \$185,553.00, prevented 69.7% of the patients from repeat radiation exposure and saved total 11,639 mGy of radiation dose consumption which signifies p value of <0.001.

Conclusion: Seventy-nine percent of interfacility transfer patients underwent CT scans prior to transfer. Since the implementation of imaging-sharing systems, the number of repeat CT scans has significantly decreased. This has resulted in increased cost saving and decreased radiation exposure to the patient. Image-sharing is an innovative practice of quality improvement and a safety measure in the rural trauma system.

LEVEL I ACADEMIC TRAUMA CENTER INTEGRATION AS A MODEL FOR SUSTAINING COMBAT SURGICAL SKILLS: THE RIGHT SURGEON IN THE RIGHT PLACE FOR THE RIGHT TIME

Rachel A. Hight MD, Sean P. Martin MD, Edgardo S. Salcedo MD, Ho H. Phan MD, Garth H. Utter* MD, Christine S. Cocanour* MD, Joseph M. Galante* MD, University of California, Davis

Invited Discussant: Nicholas Namias, MD

Introduction: As North Atlantic Treaty Organization (NATO) countries begin troop withdrawal from Afghanistan, military medicine needs programs for combat surgeons to retain the required knowledge and surgical skills. Existing programs for each military branch at various Level I academic trauma centers deliver pre-deployment training and provide a robust trauma experience for deploying surgeons. Outside of these successful programs there is no system-wide mechanism for non-deploying military surgeons to care for a high volume of critically ill trauma patients on a regular basis in an educational environment that promotes continued professional development.

Methods: We describe our military/university relationship for integrating military surgeons into a civilian trauma practice. We characterized the Level I practice using the number of trauma resuscitations, operative trauma/acute care surgery procedures, number of work shifts, operative density (defined as the ratio of operative procedures/days worked) and frequency of educational conferences. The same parameters were collected from two NATO Role III hospitals in Afghanistan during the peak of Operation Enduring Freedom (OEF). Data for two civilian Level II trauma centers, two civilian Level III trauma centers, and a Continental United States (CONUS) Military Treatment Facility (MTF) without trauma designation were collected.

Results: The number of trauma resuscitations, operative density, and educational conferences are shown in the table for the Level I trauma center compared to the different institutions. Civilian center trauma resuscitations and operative density were highest at the Level I trauma center and were only slightly lower than what was seen in Afghanistan. Level II and III trauma centers had lower numbers for both. The Level I trauma center provided the most frequent educational opportunities.

Facility Type	Trauma Designation and Number of Facilities Evaluated	Trauma Resuscitations per year	Average Number of 24hr Shifts per month	Operative Density (procedures/day)	Dedicated Educational Conferences
Civilian trauma centers	Level I - one	3000	6-10	3.53	Daily
	Level II - two	2100	2-3	1.92	Weekly
	Level III - two	600	2-3	0.83	Monthly
Military treatment facilities (MTF)	MTF, no trauma designation, CONUS - one	N/A	Clinic practice with a surgeon on-call daily	2.15	Weekly
	NATO Role III MTF, Afghanistan - two	3600	15-30	4.68	Weekly

Table: Civilian trauma center characteristics contrasted with CONUS MTF and NATO trauma centers in Afghanistan

Conclusions: In a level I academic trauma center integrated program, military and civilian surgeons have the same clinical and educational responsibilities: rounding and operating, managing critical care patients, covering trauma/acute care surgery call, and mentoring surgery residents in an integrated residency program. The Level I trauma center experience most closely mimics the combat surgeon experience seen at NATO Role III hospitals in Afghanistan compared with other civilian trauma centers. At high-volume Level I trauma centers, military surgeons will have a comprehensive trauma practice including dedicated educational opportunities. We recommend integrated programs with Level I academic trauma centers as the primary mechanism for sustaining military combat surgical skills for in the future.

RISK ASSESSMENT MODELS FOR PREDICTING VENOUS THROMBOEMBOLISM IN TRAUMA PATIENTS ARE NOT ADEQUATE

Ashley Zander DO, Jan-Michael Van Gent DO, Erik Olson MD, Steven Shackford* MD, Jayraan Badiie MPH, Beth Sise RN, Michael Sise* MD, Scripps Mercy Hospital Trauma Service

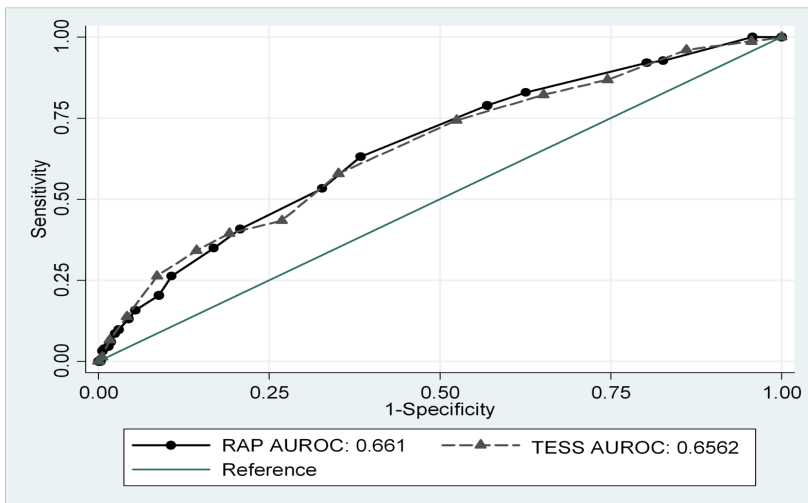
Invited Discussant: Avery Nathens, MD, PhD, MPH

Introduction: Venous thromboembolism (VTE) risk assessment models exist to stratify patients at risk for VTE and guide surveillance and prophylaxis. We evaluated two models developed specifically for trauma patients: the Trauma Embolic Scoring System (TESS) and the Risk Assessment Profile (RAP).

Methods: Clinical and demographic data of patients admitted between 7/2006-12/2011 who underwent surveillance lower extremity duplex ultrasound (LEDU) were recorded. Patients received prophylaxis according to American College of Chest Physicians guidelines. TESS and RAP scores were calculated retrospectively and compared between patients with VTE and patients without VTE. High risk, as defined by the models, is $TESS \geq 7$ and $RAP \geq 5$.

Results: 2,868 patients received surveillance LEDU. TESS was calculated for 2,140 patients; 215 developed VTE, 110 (51%) of whom had $TESS < 7$. The sensitivity and specificity at a cut point of 7 were 49% and 72%, respectively. RAP was calculated for 1,505 patients; 152 developed VTE, 26 (17%) of whom had $RAP < 5$. The sensitivity and specificity at a cut point of 5 were 83% and 37%, respectively. The receiver operating characteristic curves for the models were similar (Fig.).

Conclusion: A clinically significant number of patients who developed VTE were classified as low-risk by both TESS and RAP. The indications for VTE surveillance and chemoprophylaxis should not be based exclusively on these scores. These results suggest that additional variables should be sought to improve risk assessment for VTE following trauma.



IMPACT OF SOCIO-ECONOMIC STATUS ON HOSPITAL LENGTH OF STAY FOLLOWING INJURY: A MULTICENTER COHORT STUDY

Lynne Moore Ph.D., Brahim Cisse MSc, Brice L. Batomen MSc, Gilles Bourgeois MD,
Laval University

Invited Discussant: Karen Brasel, MD, MPH

Introduction: In the USA, around 1.9 million injury hospitalizations are recorded annually with 19.5\$ billion in acute care hospital costs alone, representing 7% of total hospital costs. Several studies have identified predictors of hospital length of stay (LOS) in trauma patients but despite the documented impact of socio-economic status (SES) on LOS in other patient populations such as cardiovascular disease, the impact of SES on LOS in trauma patients is unknown. This study aimed to examine the effect of SES on acute care LOS following injury in a setting with universal health insurance.

Methods: We conducted a multicenter cohort study involving the 56 adult trauma centers in a Canadian provincial trauma system using trauma registry and hospital discharge data collected between 2005 and 2012. SES was determined using ecological indices of material and social deprivation. Geometric Mean Ratios (GMR) and 95% confidence intervals (CI) adjusted for age, gender, comorbidities, injury severity, body region of the most severe injury, and the number of admissions in the 12 months prior to injury were generated using multivariate linear regression with a correction for hospital clusters. Analyses were stratified for age, discharge destination, and payor status.

Results: The cohort consisted of 52,122 patients with a mean LOS of 13.4 days. Patients in the highest quintile of material deprivation had a mean length of stay 4% higher than those in the lower quintile (95% CI 2%-6%). Patients in the highest quintile of social deprivation had a mean length of stay 5% higher than those in the lower quintile (95% CI 3%-7%). Patients in the highest quintile of both social and material deprivation had a mean length of stay 12% higher than those in the lowest quintile for both measures of SES (95% CI 7%- 18%).

Conclusion: Patients admitted for traumatic injury who suffer from high social and material deprivation have a longer acute care LOS in a universal-access health care system. This research suggests that interventions to facilitate access to post-discharge care for these patients may improve the efficiency of acute trauma care.

REPAIR VERSUS LIGATION OF MAJOR VENOUS INJURY AFTER PENETRATING TRAUMA: IS THERE A DIFFERENCE IN DEVELOPMENT OF PULMONARY EMBOLISM?

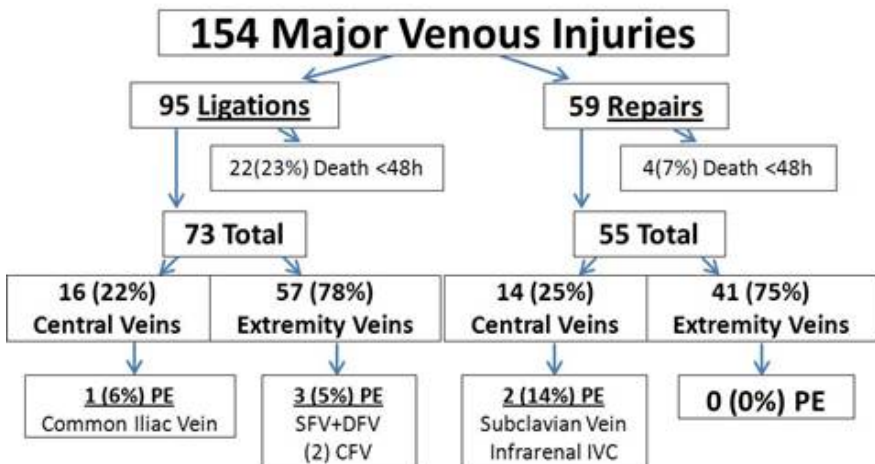
Casey J. Allen MD, Albert Hsu MD, Evan Valle MD, Nicholas Namias* MD, Alan Livingstone MD, Edward Lineen* MD, Kenneth G. Proctor* MD, University Of Miami Miller School Of Medicine

Invited Discussant: Ronald Simon, MD

Introduction: With improved rates of limb salvage and resolution of edema and phlegmasia, guidelines recommend repair of major venous injury (MVI) from penetrating trauma if the patient is hemodynamically stable. However, few studies have evaluated the rate of venous thrombotic complications following major venous injury from penetrating trauma. Repair could provide a nidus for thrombosis with subsequent propagation to the lungs; would ligation prevent this morbid complication? Our study evaluates the rate of pulmonary embolism (PE) between patients who underwent either a repair or ligation.

Methods: All MVI from penetrating trauma requiring an operation from 2003-2012 were reviewed. Information obtained includes vessels injured, repair versus ligation, presence of deep vein thrombosis (DVT) prophylaxis, and mortality. The development of DVT was obtained from venous duplex ultrasound results; PE was diagnosed by computed tomography results and cause of death analysis.

Results: The population comprised 154 patients who underwent ligation (62%) or repair (38%) of MVI. The characteristics were 88% male, age 32 ± 12 years, 74% gunshot wound, ISS 16 ± 8 , length of stay 17 ± 29 days, with an overall mortality of 21.4%. Comparing ligation vs repair groups, initial GCS was 12 ± 5 vs 14 ± 3 ($p=0.009$), initial BE -9 ± 8 vs -5 ± 5 ($p=0.006$), ISS 19 ± 12 vs 16 ± 11 ($p=NS$), units PRBCs transfused 16 ± 12 vs 12 ± 13 ($p=NS$). Of the 95 patients with ligation, 73 (77%) survived past 48 hours, and 4 (5.5%) subsequently developed PE. Of the 59 patients with repair, 55 (93%) lived past 48 hours, and 2 (3.6%) developed a PE. No cause of death was suspected from PE. In those that developed a PE, all were receiving standard DVT chemoprophylaxis. 5 patients (3 ligation, 2 repair) received antiplatelet therapy in addition to standard chemoprophylaxis, and none of these patients developed a DVT, PE, nor died. 7 patients received IVC filters (4 after confirmed PE, 3 after confirmed DVT (2 ligation, 1 repair)).



Conclusions: Following penetrating trauma, ligation of MVI does not prevent the development of PE. In fact, this population is at a heightened risk of PE. The repair of deep extremity veins has not been associated with PE. Patients that received antiplatelet therapy in addition to standard chemoprophylaxis did not develop a DVT nor PE.

ULTRASOUND VS. PALPATION GUIDED RADIAL ARTERY CATHETERIZATION: A RANDOMIZED CONTROLLED TRIAL

Lucy Ruangvoravat MD, Tobias Zingg MD, Matthew Band PA-C, Linda Maerz MD,
Christopher Erb MD, Peter Marshall MD, MPH, Michael Ditillo* DO, Kimberly Davis*
MBA, MD, Kevin Schuster* MD, Yale School of Medicine

Invited Discussant: Christine Cocanour, MD

Introduction:

Catheterization of the radial artery (CRA) is commonly done via a "blind" method with palpation of the arterial pulse guiding puncture. We hypothesized that ultrasound guidance would increase success in CRA and decrease time to CRA.

Methods:

We conducted a prospective randomized trial of ultrasound guided CRA in the Surgical and Medical Intensive Care units of a tertiary care academic medical center. Patients requiring CRA were randomly assigned to the palpation-guided (PP) or the ultrasound-guided (US) method. Each attempt was defined as time from skin puncture to appearance of an arterial waveform or withdrawal from the skin. After three failed attempts the operator would switch to the alternate method for three attempts. After six failed attempts the procedure was either aborted or attempted by a more experienced operator. Data collected included radial pulse quality, blood pressure, body mass index (BMI), need for vasopressors, and anticoagulant use. Analysis was by Chi-square, Fisher's exact test and Wilcoxon signed rank test with $p < 0.05$ significance.

Results:

Forty six patients were enrolled; 2 randomized to PP withdrew after randomizing. Of the remaining 44, 26 were randomized to US and 18 to PP. There were no differences between groups in BMI, use of vasopressors, anticoagulation, limb edema or pulse quality (all $p > 0.05$). Pulse was weak or absent in 69.2% of US patients and 61.1% of PP patients. The average time for US CRA was 666s and 591s for PP. 38.4% in the US group were successful on the first attempt and 22.2% in the PP group ($p = 0.256$). In the PP group 50% achieved CRA in 3 attempts compared to 80.8% in the US group ($p = 0.013$). There were an average of 2.04 attempts in the US group compared to 2.39 in the PP group ($p = 0.141$). Of those that failed PP and crossed over to US, 66.6% were successful compared with 0% of US crossing over to PP ($p = 0.070$). All rescue CRAs were by US; 71.4% were successful. Overall ultrasound was attempted in 35 patients (32 successful, 94.4%) and palpation was attempted in 23 (9 successful, 39.1%). The overall probability of success with ultrasound was therefore 7.10 (95% CI 2.29 – 22.00, $p < 0.001$) times that of palpation alone.

Conclusions:

With a limited number of attempts US is more likely to result in successful CRA and is also more likely to result in ultimate success. Trends toward longer operating time and higher rescue rates were observed with US suggesting a group of patients where only US will result in successful catheterization.

A PROSPECTIVE EVALUATION OF SURGICAL RESIDENT INTERPRETATION OF CT SCANS FOR TRAUMA

Reinaldo Morales MD, Rachel M. Drake M.Ed, Stephen D. Helmer Ph.D., James M.
Haan MD, The University Of Kansas School Of Medicine - Wichita

Invited Discussant: David Efron, MD

Introduction: In trauma centers across the United States, surgery residents are utilized to initiate trauma care. These residents are often relied upon to read imaging studies which direct patient care. In many cases, hospitals pay a substantial amount to outside teleradiology firms to evaluate imaging that arrives after the radiology attending is no longer in-house. The objective of this study was to compare the interpretations made by senior surgical residents to those provided by an outside teleradiology firm.

Methods: All trauma patients arriving at an American College of Surgeons verified Level 1 trauma center between 2200 and 0600 hours requiring a CT scan for evaluation of possible injury between December 2012 and December 2013 were included. Once the patient had been scanned, a trauma imaging assessment form was filled out by the senior surgical resident providing their interpretation of the CT study. At a later date, the interpretation of the outside radiologist was recorded and compared to the resident's interpretation.

Results: A total of 135 patients underwent CT evaluation during the study period. The CT interpretation of the senior surgical resident was compared to the outside radiologist. The outside radiologist and senior surgical resident rarely disagreed on the interpretation of a CT. When compared to an outside radiologist, residents were primarily in agreement with CT of the head (96.4%; $\kappa=.927$, $p<.001$), cervical spine (90.9%; $\kappa=.773$, $p<.001$), thoracic and lumbar spine (50.0%; $\kappa=.475$, $p<.001$), abdomen and pelvis (84.2%; $\kappa=.745$, $p<.001$), and chest (77.3%; $\kappa=.737$, $p<.001$). Overall, there were discrepancies in image interpretation between the resident and outside radiologist in 34 patients (25.2%). Of those 34 patients, residents missed 7 (5.2%) injuries that were clinically significant and resulted in a change of management. These missed injuries included T3 compression fracture (n=1), T6 spinous process fracture (n=1), L2 and L3 transverse process fractures (n=2), pelvic fracture (n=1), renal contusion (n=1), and a subarachnoid hemorrhage (n=1).

Conclusion: Senior surgical residents have a high rate of accuracy in reading CT imaging. Although no life-threatening injuries were missed, resident education in reading radiographic imaging in spinal regions needs to be emphasized.

WELCOME BACK: FACTORS ASSOCIATED WITH EARLY READMISSION FOLLOWING TRAUMA

Jennifer C. Roberts MD, MS, Jon Gipson MD, Joseph S. Farhat MD, Patty Reicks RN, Gregory Beilman* MD, University of Minnesota Dept of Surgery

Invited Discussant: David King, MD

Introduction: The purpose of this study was to identify patient and system-based risk factors associated with 30 day readmission at an urban level one trauma center.

Methods: A retrospective review of all adult trauma registry patients readmitted to the hospital within 30 days of discharge between 10/2011-9/2013 was performed. Patient demographics, injury data, length of stay, discharge medications, and reason for readmission were abstracted from the medical record. Descriptive statistics were calculated where appropriate using SPSS software.

Results: 5063 patients were admitted during the study period, of those 238 (4.7%) patients were readmitted within 30 days. 107 were excluded from analysis as the admissions were planned orthopedic procedures leaving 131 eligible for analysis. 51.9% of patients were male, with a mean age of 68, median ISS of 9, and mean length to readmission of 12 days. 63.3% of patients had multiple medical comorbidities (DM, HTN, CRI, or CHF), 20.6% had dementia, and 27.5% had an axis I mental illness excluding dementia. The most common mechanism of injury was falls (74%), followed by motor vehicle crashes (16%) and penetrating injury (4%). The most common reason for readmission was wound issues, followed by cardiac and pulmonary complications (table 1).

Table1. Readmission Data by System

	Wound	Cardiac	Bleeding	Pulmonary	Pain	GI	VTE	Stroke	Other
patients (%)	30 (23)	21 (16)	17 (13)	11 (8)	9 (7)	7 (5)	7 (5)	3 (1)	26 (19)
Ave. days to readmission (range)	14 (7-30)	12 (1-30)	12 (2-30)	13 (2-30)	2 (0-7)	12 (2-27)	16 (10-22)	13 (10-14)	
Diagnosis	18 SSI 6 wound breakdown	6 CHF 5 MI 5 arrhythmia	10 SDH 5 GIB	9 PNA		2 N/V 2 PSBO	5 PE 2 dvt		9 falls 8 confusion 5 UTI
Sent from skilled nursing (%)	14/30 (50)	15/21 (72)	15/17 (88)	9/11 (81)	5/9 (56)	0/7 (0)	2/7 (28)	3/3 (100)	16/26 (62)

9 patients were readmitted with a new fall. The mean time to readmission was 12 days. In 102/131 patients, the trauma service was not notified of readmission. Following readmission, fewer patients were discharged home and more required home health resources (Table 2). Changes were made in home medications in 113/131 patients: 75/131 new opioids, 44/131 new anticoagulation, 31/131 new blood pressure/diuretic medication.

Table 2. Discharge Location by Admission

	Original disposition	Readmission Disposition
Home (%)	46/131 (35)	30/131 (25)
Home Health (%)	7/131 (5)	20/131 (14)
Skilled Nursing Facility (%)	78/131 (60)	81/131 (61)

Conclusions: In contrast to the trauma population as a whole, patients readmitted within 30 days at our institution were elderly men or women with multiple comorbidities who sustained falls prior to admission. The trauma team is infrequently notified of these readmissions. Improved pain control prior to discharge, patient education of pain expectations, and earlier wound surveillance regardless of discharge location may help reduce these readmissions. Many readmissions occur at least 14 days following discharge. These are likely related to elderly patient comorbidities and may represent alterations in patient physiology following trauma. Commonly, medication changes are made at the time of initial discharge and could be a cause of readmission. Closer follow up with a primary care provider after discharge may be helpful in this population.

FIBRINOLYSIS DOES NOT OCCUR FOLLOWING RESUSCITATION IN SEVERE HEMORRHAGIC SHOCK REQUIRING IMMEDIATE OPERATION

Mona Taleb MD, Anna M. Ledgerwood* MD, Wayne State University

Invited Discussant: Mitchel Cohen, MD

INTRODUCTION: Hemorrhagic shock (HS) causes immediate hypofibrinogenemia and fibrinolysis. This study assesses fibrinolysis following resuscitation in patients (pts) taken directly to surgery for control of severe hemorrhage.

METHODS: 317 measurements of fibrinogen (FI), fibrin split product (FSP), and fibrin monomer (FM) were made in 268 pts following resuscitation for HS in the OR 3.9 hrs after injury (32 pts), postoperatively at 20 hrs (153 pts), at 35 hrs (94 pts), at 52 hrs (64 pts), at 71 hrs (53 pts), and 19 days (8 pts). During OR they received 14.3 RBC units, 851 ml FFP, and 11.5 L balanced electrolyte solution (BES).

RESULTS: OR FI levels were low, rose to low normal levels by 20 hrs and high normal by 35 hrs, and increased to supernormal levels by 52 hrs, 71 hrs, and day 19. FSP and FM were absent during operation and did not appear until FI levels were within the normal range or greater than normal (Table).

Table	OR (4 hrs)	20 hrs	35 hrs	52 hrs	71 hrs	19 days
FI (mg/dL)*	159±13	231±13	373±18	448±15	604±42	500±47
FSP (pos/#pts) ⁺	0/25	1/34	8/35	12/37	24/36	10/15
FM (pos/#pts) ⁺	0/29	0/37	2/41	1/31	4/11	3/8

Mean ± SE; ⁺ Positive value/# pts

CONCLUSION: Low FI during OR and at 20 hrs is due to bleeding, dilution from BES, and extravascular relocation; lysis is absent. Significant lysis does not occur until FI levels are supernormal. Early antifibrinolytic therapy after resuscitation is not indicated.

INTRACRANIAL PRESSURE MONITORING DURING THERAPEUTIC CEREBROSPINAL FLUID DRAINAGE: “ONLY PART OF THE STORY?”

Raymond Fang* MD, Catriona Miller Ph.D., Shiming Yang Ph.D., Yao Li MS, Colin F. Mackenzie M.B.,Ch.B., Hegang Chen Ph.D., Katharine R. Colton BS, Thomas M. Scalea* MD, Deborah M. Stein* MD,MPH, Peter F. Hu Ph.D., US Air Force

Invited Discussant: Susan Rowell, MD

Introduction: The 2007 Brain Trauma Foundation Guidelines for management of severe traumatic brain injury (TBI) recommends intracranial pressure (ICP) monitoring utilizing an intraventricular catheter (IVC) for salvageable patients with an abnormal head computed tomography scan. IVCs not only provide accurate and reliable ICP measurements, but they also enable therapeutic drainage of cerebrospinal fluid (CSF). Because standard IVCs cannot simultaneously drain CSF and measure ICP, ICP is then often only measured hourly during brief manual closures of the circuit. We hypothesized that unrecognized, but clinically significant, ICP fluctuations occur during periods of CSF drainage in the care of these patients.

Methods: Adult admissions to a Level I urban trauma center between 2008 and 2010 were reviewed to seek patients with concurrent IVC and intraparenchymal ICP monitor (IPM) placements. Time periods when ICP data were recorded from both devices were analyzed and compared. While IPM ICP measurements were autonomously recorded at 6 second intervals, IVC ICP values were abstracted from nursing entries into the patients' vital signs flow sheet and then presumed to remain static until the next IVC ICP measurement was recorded.

Results: Eighty-one patients were identified with concurrent IVC and IPM ICP data over 5,579 hours of monitoring. The mean of all the differences between ICP values measured by IVC vs. IPM showed an IVC bias of -2.1 mm Hg (SD +/- 6 mm Hg). Limiting analysis to periods when IPM ICP ≥ 15 and ≥ 20 mm Hg, the IVC bias increased to -6.6 (+/-7.8) and -11.1 (+/-9.6) mm Hg.

Conclusions: Neurocritical care practice using IVCs for therapeutic CSF drainage with hourly ICP measurements undervalues ICP when compared to continuous IPM measurement. This difference is more pronounced in patients with intracranial hypertension and may contribute to additional secondary brain injury and suboptimal functional outcomes.

Complications of Damage Control and Definitive Laparotomy in Combat: 2002-2011

Thomas A. Mitchell MD, Christopher White MD, Lorne Blackbourne MD, John Holcomb* MD, San Antonio Military Medical Center

Invited Discussant: C. William Schwab, MD

Introduction: Damage control laparotomy (DCL) in an austere environment is an evolving surgical treatment modality. We evaluated the demographics, organ injury burden, complications, and mortality for United States (US) soldiers undergoing definitive laparotomy (DL) and DCL in Iraq and Afghanistan.

Methods: A retrospective evaluation of all patients surviving 24 hours who underwent a laparotomy from 2002-2011 during Iraq and Afghanistan was performed. Utilizing ICD-9 Procedure codes, DCL was defined as: a patient undergoing operative procedures at two distinct North American Treaty Organization (NATO) Role III medical treatment facilities (MTFs); a NATO Role II and III MTFs, and/or having the ICD-9 procedure code 54.12, for Re-Opening of Recent Laparotomy Site. Definitive laparotomy (DL) was defined as patients undergoing one operative procedure at one NATO Role II or III MTF. Demographic, mortality, intra-or-retro-peritoneal operative interventions, and complications were compared.

Results: DCL comprised 26.4% (n=330) of all 1,248 laparotomies performed between March 2002 to September 2011. Patients undergoing DCL compared to DL had an ISS of 28.0 (IQR 19, 36) versus 22 (IQR 14, 30), respectively ($p<0.05$). DCL patients had more intra-or-retroperitoneal organs requiring operative intervention, 1.8 ± 1.4 versus 1.0 ± 1.0 ($p<0.05$). Colonic operative procedures occurred in 50% (n=165) of DCLs compared to in 24.2% (n=222) of DLs ($p<0.05$). DCL occurred in 21.7% (n=177) and 35.3% (n=153) of all laparotomies in Iraq and Afghanistan ($p<0.001$). DCL occurred in 37.1% (n=117) and 24.6% (n=201) of all firearm and explosive device injuries ($p<0.05$). Abdominal and extremity/pelvic abbreviated injury scores were directly proportional to predicting DCL compared to DL ($p<0.05$). Intra-abdominal, acute respiratory distress, and thromboembolic complications for DCL versus DL were 8.5% and 5.6% ($p=0.07$), 2.1% and 0.8% ($p=0.06$), and 1.5% and 0.7% ($p=0.17$), respectively. Theater mortality for DCL and DL were 1.5% and 1.4% ($p=1.0$).

Conclusions: Implementation of DCL in an austere environment is a safe and effective means to care for severely injured combat wounded across distinct geographic locations; utilization of this data will provide the foundation to codify a DCL theater clinical practice guideline for future deployed military surgeons.

STRESS-INDUCED HYPERGLYCEMIA IS ASSOCIATED WITH HIGHER MORTALITY IN SEVERE TRAUMATIC BRAIN INJURY

Patrick L. Bosarge MD, Russell L. Griffin Ph.D., Jeffrey D. Kerby* MD,Ph.D.,
University of Alabama Birmingham

Invited Discussant: Jay Doucet, MD

Introduction: An association between stress induced hyperglycemia (SIH) and increased mortality has been demonstrated following trauma. Experimental animal model data regarding the association between hyperglycemia and outcomes following traumatic brain injury (TBI) is inconsistent suggesting hyperglycemia may be harmful, neutral, or beneficial. The purpose of this study is to examine the effects of SIH vs diabetic hyperglycemia (DH) on severe TBI.

Methods: Admission glycosylated hemoglobin (HbA1c), glucose levels, and comorbidity data were collected over a 4-year period from September 2009 to December 2013 for patients with severe TBI (i.e., admission GCS of 3-8). Diabetes mellitus (DM) was determined by patient history or admission HbA1c of 6.5% or more. SIH was determined by absence of DM and admission glucose of 200 mg/dL or more. A Cox proportional hazards model adjusted for age, sex, injury mechanism, and injury severity score was used to calculate hazard ratios (HRs) and associated 95% confidence intervals (CIs) for the association between SIH and the outcomes of interest.

Results: During the study period, 986 trauma patients with severe TBI were admitted and had available glucose, HbA1c, and comorbidity data. A total of 286 patients were admitted with hyperglycemia; 228 patients (79.7%) were diagnosed with SIH and 58 patients (20.3%) were diagnosed with DH. Compared to normoglycemic, non-diabetic, severe TBI patients, SIH patients had a two-fold increased risk of death (HR 1.95, 95% CI 1.55-2.44), and DH patients had a 50% increase in mortality risk (HR 1.48, 95% CI 1.00-2.19).

Conclusion: Hyperglycemia is associated with higher mortality after severe TBI. This association is stronger in patients with SIH. Further research is warranted to identify mechanisms causing hyperglycemia and subsequent worse outcomes after TBI.

DETERMINING FACTORS THAT IMPROVE RESPONSE TO INPATIENT REHABILITATION IN PATIENTS WITH MODERATE TO SEVERE TRAUMATIC BRAIN INJURY

Fred S. McLafferty BA, Galinos Barmparas MD, Pamela Roberts Ph.D., Alicia Ortega BS, Miriam Nuño Ph.D., Chirag G. Patil MD, MS, Eric Ley* MD, Cedars-Sinai Medical Center

Invited Discussant: Garth Utter, MD

Introduction: We set out to determine factors that improve response to inpatient rehabilitation among patients with moderate to severe traumatic brain injury (TBI).

Methods: A retrospective cohort study of moderate to severe TBI patients who were admitted to the inpatient rehabilitation service at an academic, level I trauma center between 2002 and 2012. Each patient was assigned a level, 1-7, which was determined by equally spaced intervals of functional independence measure (FIM) scores. A patient with improvement by 2 levels was considered a responder. A forward logistic regression was utilized to identify factors associated with response to inpatient rehabilitation.

Results: Over the 10-year study period, a total of 2,211 patients were treated at our facility for TBI, of which 192 (9%) were admitted to inpatient rehabilitation. Of those, a total of 102 (55.7%) were considered responders, with the largest proportion improving in mobility (73.2%), followed by self-care (60.7%), sphincter control (42.1%), and communication/social cognition (21.3%). Patients that responded to rehab were significantly younger (52.3 years vs. 61.6, $p<.0001$) and had on average longer rehab stays (15.3 days vs. 12.3, $p<.0001$) than their non-responding counterparts. Once we adjusted for injury severity score (ISS), hospital length of stay (LOS), and ICU LOS, being younger than age 65 (<65 , $HR=0.24$, $p<.0003$), having a higher head abbreviated injury scale (5 vs. 4, $HR=3.06$, $p<0.02$), and having a longer rehabilitation LOS (>14 days, $HR=3.86$, $p<.001$) were all associated with increased response to inpatient rehabilitation. Overall injury severity, as measured by the ISS, had no association with determining responders to inpatient rehabilitation ($HR=1.00$, $p=0.32$).

Conclusion: Of patients who qualify for inpatient rehabilitation, only one out of two responds to treatment. Mobility and self-care are the major components of overall improvement in functional independence. Younger age and longer rehabilitation times are associated with response to rehabilitation. Further efforts should be placed on identifying and facilitating transfer of traumatic brain injury patients to inpatient rehabilitation.

THE DISPARITY GAP IN TRAUMA DOES NOT NARROW FOR UNINSURED ADULTS SUFFERING SEVERE INJURY

Jon M. Gerry MD, Thomas G. Weiser MD, David A. Spain* MD, Kristan L. Staudenmayer MD, Stanford University, Trauma And Acute Care Surgery

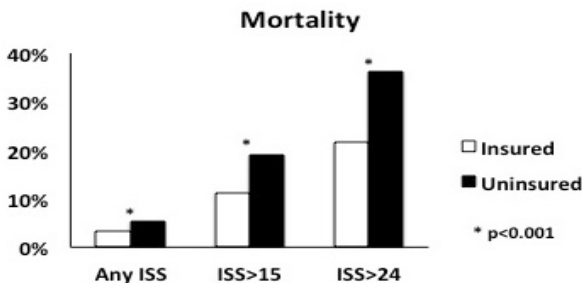
Invited Discussant: Adil Haider, MD

Introduction: Lack of access to trauma care for the uninsured results in worse outcomes. However, once patients arrive at a trauma hospital, the care received should be the same. We hypothesized that disparities in outcomes would lessen with increases in injury severity.

Methods: We performed a retrospective analysis of the 2010 National Sample Program from the National Trauma Databank. We included adults (18 to 64 years) treated at level I or II trauma centers, and excluded patients with unknown insurance status, injury severity scores (ISS), or hospital disposition. Patients with insurance were defined collectively as patients with private insurance, Medicare or Medicaid. The primary outcome was in-hospital mortality. Unadjusted and adjusted analyses were performed. All observations are presented as weighted numbers.

Results: There were 310,000 injured patients included in the analysis and 90,000 (29%) were uninsured. The uninsured were younger (35 vs. 41 yrs, $p<0.001$) and more often male (81% vs. 68%, $p<0.001$). Uninsured patients were less severely injured as measured by mean injury severity score (ISS 9.6 vs. 10.7, $p=0.007$) and more often injured by a penetrating mechanism (26% vs. 10%, $p<0.001$). The uninsured were more likely to die regardless of injury severity (11% vs. 19%, ISS>15, $p<0.001$; 22% vs. 36%, ISS>24, $p<0.001$). Admissions directly to the ICU and mean ventilator free days were not significantly different between the two groups. In the adjusted analysis, uninsured status was associated with higher mortality, even at high injury severity (OR 1.67 for uninsured vs insured with ISS>15, $p=0.003$).

Conclusion: Contrary to our hypothesis, being uninsured is independently associated with higher mortality across the ISS spectrum, suggesting increased vulnerability of this population throughout U.S. trauma systems. Since all patients in this study did not suffer from lack of access to trauma care and because these patients likely received similar care based on their injury severity and ICU utilization, this suggests patient-level factors may be playing an important role in driving poor outcomes.



BLUNT DUODENAL TRAUMA, IS NON-OPERATIVE MANAGEMENT SAFE?

Matthew Bradley MD, Brandon Bonds MD, David Dreizin MD, Katie Colton BS,
Kathirkamanthan Shanmuganathan MD, Thomas Scalea* MD, Deborah Stein*
MD,MPH, R Adams Cowley Shock Trauma Center

Invited Discussant: Anna Ledgerwood, MD

Introduction: Clear signs of duodenal injury (DI), pneumoperitoneum and/or oral contrast extravasation mandate laparotomy. However, appropriate management when CT has indirect evidence of DI (duodenal hematoma or periduodenal fluid) is unclear. We evaluated the ability of indirect signs to identify DI and evaluated success of expected management, hypothesizing patients with indirect evidence of DI on CT can be safely managed non-operatively.

Methods: We retrospectively reviewed all patients with a diagnosis of blunt DI and CT scan with duodenal hematoma or periduodenal fluid collection treated between January 2003 and January 2013. Children (age <18 years) and penetrating trauma were excluded. Laboratory values, operative findings, Injury Severity Score (ISS) and Abbreviated Injury Score (AIS) were recorded. Patients having immediate laparotomy were compared to those initially managed conservatively. Student t-tests were used to compare groups.

Results: We identified 84 patients. Nine had findings diagnostic for DI and were excluded from further analysis. 36 patients with indirect signs (48%) underwent immediate operative exploration and 39 (52%) were initially managed non-operatively. There was no difference in admission laboratory values, but mean ($\pm$ SD) ISS (35 ± 12 vs 26 ± 12 , $p<0.001$) and abdominal AIS (3.3 ± 1 vs 2.5 ± 0.8 , $p<0.001$) were higher in those with immediate operation. The incidence of DI requiring operative repair was 12% (9 of 75). Seven of 36 (19%) explored urgently had a DI requiring surgical repair while 29 of 36 (81%) had no DI or minor injury not requiring surgical therapy. Of those managed non-operatively, 7 of 39 (18%) failed observation but only two (5%) of those required duodenal repair. Both had worsening findings on interval CT scan. There was no significant difference in ICU (8.6 ± 11 vs 10.4 ± 14 , $p=0.38$) and hospital (20.7 ± 15 vs 22.9 ± 21 , $p=0.49$) lengths of stay between those that failed non-operative management and those operated on immediately. None of the patients that failed conservative management died.

Conclusion: Observation of patients with indirect sign of DI fails in about 20% of patients, but failure rate due to DI is low. Conservative management in the appropriately selected patient is reasonable and follow-up CT scan may help. Higher ISS may suggest the need for urgent operation.

MICROARRAY ANALYSIS OF GENE EXPRESSION PROFILES IN TRAUMATIC BRAIN INJURED PATIENTS: IMPACT OF PREHOSPITAL FLUID RESUSCITATION

Matthew J. Delano MD,Ph.D., Maria Y. Shiu MD, Shawn Rhind Ph.D., Carl Virtanen
Ph.D., Joseph Cuschieri* MD, Eileen Bulger* MD, University of Washington

Invited Discussant: Eric Ley, MD

Introduction: Traumatic brain injury (TBI) is the leading cause of death following blunt trauma. Therapeutic intervention focuses on minimizing secondary brain injury by supporting systemic perfusion and reducing intracranial pressure with the administration of hypertonic fluids. Cerebral recruitment of blood leukocytes exacerbates endogenous neuroinflammatory pathways and potentiates secondary brain injury. However, the impact of hypertonic fluid on leukocyte genomic expression is unknown. We hypothesize that peripheral blood leukocyte gene expression profiles vary based on the type of hypertonic fluid administered and may influence the extent of secondary brain injury.

Methods: In a multicentre, 3-arm, double blinded, randomized controlled trial. Patients with severe TBI were administered either 7.5% hypertonic saline (HS), 7.5% hypertonic saline + 6% dextran 70 (HSD), or 0.9% normal isotonic saline (NS) as the initial prehospital resuscitation fluid. Seventy-nine patients and ten age-matched healthy adult volunteers were enrolled. Upon hospital admission peripheral blood samples were drawn directly into PAXgene tubes for mRNA stabilization and extraction. Microarray hybridization was carried out with Agilent Genotypic Technologies.

Results: Hierarchic clustering analysis demonstrated 11788 probes differentially expressed between TBI patients and controls (FDR0.05). Of the 11788 probes, 3236 probes exhibited a two-fold or greater change across all cellular, molecular and biological categories, with immune modulation, inflammatory mediation and wounding responses most represented. Supervised analysis between hypertonic fluid treatment groups revealed 2082 probes that were differentially expressed (FDR0.05). Principle component analysis based on the 2082 probes was able to differentiate the genomic expression patterns between treatment groups. Further analyses between treatment groups revealed 834 probes differentially expressed between NS and HS groups, 259 between the NS and HSD groups, and 460 between the HSD and HS groups. Pathway analysis discovered that many probes represented purine base metabolism and DNA packaging and assembly.

Conclusion: In this study we demonstrated that peripheral blood leukocyte genomic signatures vary significantly with the type of prehospital hypertonic fluid administered. Moreover, the genomic alterations represent immune modulatory and inflammatory pathways that may impact and predict the evolution of secondary brain injury and allow more timely intervention to improve outcome following severe TBI.

CAN MESENCHYMAL STEM CELLS REVERSE CHRONIC STRESS-INDUCED IMPAIRMENT OF WOUND HEALING FOLLOWING TRAUMATIC INJURY?

Amy V. Gore MD, Letitia E. Bible MD, Kim J. Song MD, Walter D. Alzate MS,
Alicia M. Mohr*MD, David H. Livingston* MD, Ziad C. Sifri* MD, University of Medicine
and Dentistry New Jersey

Invited Discussant: Gregory Victorino, MD

Introduction: One week following unilateral lung contusion (LC), rat lungs demonstrate full histologic recovery. When animals undergo LC plus the addition of chronic restraint stress (CS), wound healing is significantly delayed. Mesenchymal stem cells (MSC) are pluripotent cells capable of immunomodulation that have been the focus of much research in wound healing and tissue regeneration. We hypothesize that the addition of MSCs will abrogate this impaired healing in the setting of CS.

Methods: Male Sprague-Dawley rats (n=6-7/group) were subjected to LC/CS with or without the injection of MSCs. MSCs were given as a single IV dose of 5×10^5 cells in 1mL IMDM media at the time of LC. Rats were subjected to two hours of restraint stress on days 1-6 following LC. Seven days following injury, rats were sacrificed and lungs examined for histologic evidence of wound healing using a well-established histologic lung injury score (LIS) to grade injury. LIS examines inflammatory cells/high power field (hpf) averaged over 30 fields, interstitial edema, pulmonary edema, and alveolar integrity with scores ranging from 0-11. Data analyzed by ANOVA followed by Tukey's multiple comparison test, expressed as mean $\pm$ SD.

Results: As previously shown, seven days following isolated LC, LIS has returned to 0.83 ± 0.41 , with a subscore of zero for inflammatory cells/hpf. The addition of CS results in a LIS score of 4.4 ± 2.2 , with a subscore of 1.9 ± 0.7 for inflammatory cells/hpf. Addition of MSC to LC/CS decreased LIS score to 1.7 ± 0.8 with a subscore of zero for inflammatory cells/hpf.

LIS Total and Subgroup Score Seven Days Following Injury					
Group	Inflammatory cells/hpf	Interstitial Edema	Pulmonary Edema	Alveolar Integrity	Total LIS
LC	0 $\pm$ 0	0.75 $\pm$ 0.5	0 $\pm$ 0	0 $\pm$ 0	0.8 $\pm$ 0.4
LC/CS	1.9 $\pm$ 0.7*	1.4 $\pm$ 0.5	0.4 $\pm$ 0.5	0.7 $\pm$ 0.8	4.4 $\pm$ 2.2*
LC/CS + MSC	0 $\pm$ 0	1.2 $\pm$ 0.4	0 $\pm$ 0	0.5 $\pm$ 0.5	1.7 $\pm$ 0.8**

Data presented as mean score $\pm$ standard deviation; * $p < 0.05$ vs LC ** $p < 0.05$ vs LC/CS

Conclusion: Stress-induced impairment of wound healing is reversed by addition of MSCs given at the time of injury in this rat lung contusion model. This improvement in lung healing is associated with a decrease in the number of inflammatory cells. Further study into the mechanisms by which MSCs hasten wound healing is warranted.