

Session I

Paper 1 7:50AM

**OPERATIVE REPAIR OR STENT/GRAFT IN BLUNT TRAUMATIC THORACIC AORTIC INJURIES: RESULTS OF A MULTICENTER AAST STUDY**

Demetrios Demetriades MD, PhD, George Velmahos MD, PhD, Thomas M. Scalea MD, Gregory J. Jurkovich MD, Pedro Teixeira MD, James V. O'Connor MD, Riyad Karmy-Jones MD, Mark R. Hemmila MD, Forrest O. Moore MD, Jason London MD, Michael Sugrue MD, Michael J. Singh MD, Konstantinos Spaniolas MD, Marius Keel MD, Jonathan Hill MD, Mathew Wall MD, Ernest E. Moore MD, Alvaro Razur MD, Daniel Margulies MD, Valerie Malka MD, AAST Multi Institutional Trial Committee

**Invited Discussant:** Kenneth L. Mattox, M.D.

**Introduction:** The purpose of this AAST multicenter study is to assess the early efficacy and safety of endovascular stent grafts (SG) in traumatic thoracic aortic injuries and compare outcomes with the standard operative repair (OR).

**Patients and Methods:** Prospective, multicenter study. The following data were collected: age, blood pressure and GCS on admission, type of aortic injury, ISS, AIS, transfusions, survival, ventilator days, complications, and ICU and hospital days.

**Results:** 123 patients met the criteria for inclusion. 84 patients (68%) were initially selected for SG and 39 (32%) for OR. SG was selected in 70% of patients with major extrathoracic injuries and 64% of patients with no major extrathoracic injuries. SG patients were significantly older than OR patients. Five patients (6.0%) in the SG group needed conversion to OR because of technical failure. There were 12 endoleaks (14.3%), two of which needed OR. The overall mortality was 6.0% in the SG group and 15.4% in the OR group ( $p=0.10$ ). The mortality in patients with major extrathoracic injuries was 7.7% and 14.3% ( $p=0.44$ ) respectively and in patients with no major extrathoracic injuries it was 0% vs 20.0% ( $p=0.12$ ) respectively. The SG group was associated with a significantly lower incidence of complications (64% vs 42%,  $p=0.02$ ) and a trend toward shorter ICU and hospital stay. Seven patients (8.3%) in the SG had serious procedure-related complications. Procedure-related paraplegia developed in one case in each group.

**Conclusions:** Most surgeons select SG for traumatic TA ruptures, irrespective of associated injuries and injury severity. SG is associated with significantly fewer complications and possibly lower mortality and ICU and hospital stay, but there is a considerable risk of serious device-related complications. Better selection of patients and improved devices are needed to reduce the risks of SG.

**ADRENAL INSUFFICIENCY FOLLOWING A SINGLE DOSE OF  
ETOMIDATE FOR RAPID SEQUENCE INDUCTION: A PROSPECTIVE  
RANDOMIZED STUDY**

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**Invited Discussant:** Leonard J. Weireter, Jr., M.D.

**Introduction:** The administration of etomidate for rapid sequence induction (RSI) has been linked to subsequent adrenocortical insufficiency in non-trauma patients. However, etomidate-related adrenocortical insufficiency has not been well studied in the trauma population.

**Purpose:** We performed a prospective, randomized, controlled study to determine the incidence of adrenocortical insufficiency and its significance during the first 24 hours of resuscitation following RSI in trauma patients.

**Methods:** Adult trauma patients admitted to our Level I trauma center requiring RSI were randomized to receive either etomidate 0.3mg/kg and succinylcholine 1mg/kg (E group) or fentanyl 100 µg, midazolam 5mg, and succinylcholine 1mg/kg (FM group) for induction. A baseline serum cortisol level was drawn prior to RSI. Four to six hours after RSI a second serum cortisol level was drawn. A cortrosyn stimulation test (CST) was performed.

**Results:** 30 patients were enrolled: 18 E group patients and 12 FM group patients. No statistical difference was detected between the two groups with respect to age, injury severity score (ISS), and baseline serum cortisol. Mean serum cortisol levels were significantly lower in E group patients than in FM group patients four to six hours after intubation (18.2 vs. 27.8µg/dL,  $p<0.05$ ). A normal response to CST (increase  $>9\mu\text{g/dL}$  or baseline  $>34\mu\text{g/dL}$ ) occurred in 100% of FM group patients vs. 5.9% of E group patients ( $p<0.05$ ). Patients in the E group required longer ICU lengths of stay (mean 6.3 vs. 1.5 days,  $p<0.05$ ), more ventilator days (mean 28 vs. 17 days,  $p<0.05$ ), and longer hospital lengths of stay (mean 11.6 vs. 6.4 days,  $p<0.05$ ).

**Conclusions:** The use of etomidate for RSI in trauma patients led to chemical evidence of adrenocortical insufficiency and may have contributed to increased hospital and ICU lengths of stay and increased ventilator days. Further studies should be considered to evaluate the safety profile of this drug in trauma patients.

**TRAUMA QUALITY IMPROVEMENT USING RISK-ADJUSTED OUTCOMES**

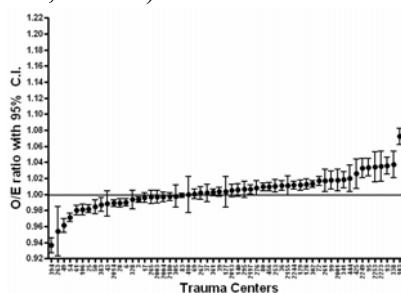
Shahid Shafi, M.D., M.P.H.\*, Jennifer Parks, M.P.H., Avery B. Nathens, M.D., Ph.D., M.P.H.\*, Larry M. Gentilello, M.D.\*, University of Texas Southwestern Medical School, Dallas, TX (SS, JP, LMG), and University of Toronto, Toronto, Canada (ABN)

**Invited Discussant:** Jana B.A. MacLeod, M.D., M.Sc.

**Purpose:** The National Surgical Quality Improvement Program (NSQIP) has improved the quality of surgical care by tracking risk-adjusted patient outcomes at Veterans Affairs hospitals. Unlike NSQIP, the trauma center verification program of the American College of Surgeons (ACS) focuses on availability of optimal resources, not outcomes. We hypothesized that significant institutional variations in outcomes exist across similar level ACS verified trauma centers, despite verification of optimal resources.

**Methods:** The National Trauma Data Bank ('99-'04) was used to identify adult patients (age 16–99 years) who were treated at ACS verified Level I trauma centers that submitted at least 1000 patients during the five year study period (220,202 patients from 58 trauma centers, excluding dead upon arrival). Multivariate logistic regression was used to determine expected survival for each patient, adjusted for age, gender, race, injury mechanism, transfer status, and injury severity (ISS, GCS, systolic blood pressure). The model was developed in a random half of the data, validated in the other half, then applied to the entire study population with excellent discrimination (AUC 0.947, 95% CI 0.945 to 0.949). Observed-to-Expected survival ratios (O/E ratios, 95% CI) were used to rank trauma centers as good (O/E > 1), poor (O/E < 1), or average performers (O/E ratio overlapping 1).

**Results:** Almost half of the centers performed significantly different than their risk-adjusted expectation. Fourteen were good performers, 11 were poor performers, while the rest were average.



**Conclusions:** The trauma center verification process in its present form does not appear to ensure optimal outcome across all verified centers. If validated using robust data collection and risk-adjustment techniques, these findings suggest significant room for trauma quality improvement by replicating structures and processes of good performing trauma centers.

**THE TRAUMA SURGEON'S CURRENT PRACTICE: CAN WE DELIVER ACUTE CARE SURGERY?**

C. Clay Cothren, MD\*; Ernest E. Moore, MD\*; David B. Hoyt, MD\*, Denver Health Medical Center and the University of California, Irvine, CA

**Invited Discussant:** Donald D. Trunkey, M.D.

**Background:** The evolving discipline of acute care surgery as an expansion of trauma surgery is undergoing intense critique. As we envision this new paradigm of surgical practice, an evaluation of our current status across the nation's trauma centers is an essential step. The *purpose* of this study is to determine the practice patterns of trauma surgeons at major trauma centers throughout the United States.

**Methods:** A survey was sent to the trauma directors of the 1288 designated trauma centers in the United States, as listed by the American Trauma Society. As proposed, acute care surgery would encompass performing emergent abdominal, vascular, and thoracic trauma procedures as well as providing critical care. The addition of simple orthopedic and neurosurgical procedures has been considered.

**Results:** The survey response rate was 72% among the level I/II/III centers (n=515) with 92% of level I, 72% of level II, and 59% of level III centers responding. Of the 169 level I centers, 31 (18%) reported their trauma surgeons perform the full complement of thoracic, vascular, and abdominal cases. Trauma surgeons managed the full range of injuries at 11 (6%) of the 187 level II centers and 7 (4%) of the 159 level III centers. Of these 49 centers, only 41% of surgeons perform elective thoracic and vascular cases. The remaining 466 centers enlist a combination of vascular and thoracic surgeons to manage trauma patients. Of these trauma centers, trauma surgeons performed cranial burr holes at 8, placement of ICP monitors at 4, and open fracture washout at 3.

**Conclusions:** The model of the acute care surgeon is attractive and timely, but only a limited number of trauma surgeons currently practice this proposed range of operative procedures; even fewer surgeons have an elective surgical practice to maintain key operative skills. Fellowship training programs need to incorporate vascular and thoracic procedures to enable the specialty of acute care surgery.

**IMMEDIATE ENDOSCOPIC REALIGNMENT: A NEW TREATMENT  
PARADIGM FOR TRAUMATIC URETHRAL INJURY**

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**Invited Discussant:** Richard A. Santucci, M.D.

**Background:** The traditional management of a urethral injury requires suprapubic drainage and delayed repair. Advances in endoscopic techniques have facilitated early realignment and transurethral catheterization of the injured segment as a new management option. The purpose of this study was to investigate the outcomes of patients undergoing Immediate Endoscopic Realignment (IER) compared to Delayed Treatment (DT).

**Methods:** Male trauma patients sustaining a urethral injury admitted to a Level I trauma center were prospectively identified and followed through their course of treatment. Injury demographics and outcomes were compared for IER vs DT. The primary outcome measures were time to spontaneous voiding and urethral stricture rate.

**Results:** Of the 21 patients with urethral injuries, 14 (67%) had successful IER and 7 (33%) had DT (4 IER failures and 3 primary DT). Mean follow-up was 7 months (range 14 days to 1.7 years). IER and DT groups were similar with regards to age ( $30 \pm 16$  vs  $24 \pm 6$ ), mechanism of injury (blunt vs penetrating), location of urethral injury (anterior vs posterior), GCS ( $13 \pm 3$  vs  $12 \pm 6$ ), ISS ( $14 \pm 11$  vs  $20 \pm 6$ ), and associated injuries (pelvic fractures and intra-abdominal injuries). Mean time to IER from admission was  $32 \pm 80$  hours (range 1hr-2.8 days). Patients undergoing IER had a significantly shorter time to spontaneous voiding ( $35 \pm 23$  vs  $229 \pm 79$  days,  $p=0.001$ ) and had a significantly decreased rate of stricture formation (14% vs 100%,  $p<0.0001$ ). All DT patients required formal surgical urethroplasty while the 2 (14%) IER patients with strictures only required outpatient clinic dilatation.

**Conclusion:** Contrary to the traditional Delayed Management approach, Immediate Endoscopic Realignment results in a significantly reduced time to spontaneous voiding with less risk of urethral stricture, possibly avoiding the need for surgical urethroplasty and long-term suprapubic urinary diversion.

**DECREASING MAGNITUDE OF MULTIPLE ORGAN DYSFUNCTION SYNDROME (MODS) DESPITE INCREASINGLY SEVERE CRITICAL SURGICAL ILLNESS: A 17-YEAR LONGITUDINAL STUDY**

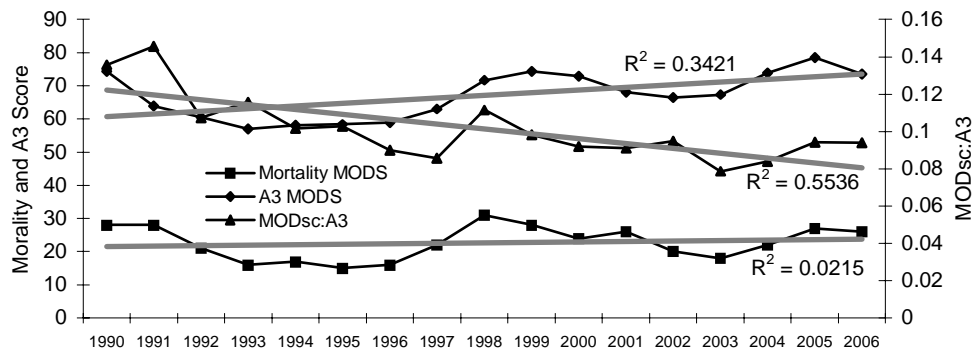
Philip S. Barie, MD, MBA\*, Lynn J. Hydo, MBA, RN, Jian Shou, MD, Soumitra R. Eachempati, MD\*, Weill Medical College of Cornell University, New York, NY

**Invited Discussant:** Louis H. Alarcon, M.D.

**Objective:** MODS remains prevalent and the leading cause of mortality (M) in the ICU. Improvements in ICU care in the last 5-7 years (e.g., tight glyceimic control, activated protein C, fewer transfusions causing fewer healthcare-associated infections) may have decreased the incidence/magnitude/M of MODS, as hypothesized in this study.

**Methods:** Longitudinal 17-year prospective study of 11,314 ICU patients (academic/tertiary unit, Level 1 trauma center), 5,157 (45.5%) of whom developed any degree of MODS (Marshall score, cumulative). Parameters included: Admission APACHE III (A3), MOD score (MODsc), M, incidence/magnitude of MODS, and calculated ratio of MODsc:A3. Analyses ( $X \pm SEM$ ,  $\chi^2$ , repeated-measures ANOVA, linear regression) were performed for calendar-year intervals beginning in 1990 through 2006.

**Results:** Among MODS patients, mean MODsc was  $6.3 \pm 0.1$ , and M was 22%. A3 increased significantly ( $P < 0.0001$ ) over time (Figure), but M was unchanged ( $r^2$ , 0.02). Adjusted for illness severity (MODsc:A3), the magnitude of MODS decreased significantly ( $p < 0.0001$ ) during the time period.



**Conclusions:** Despite significant increases in admission A3 score over 17 years, the adjusted magnitude of MODS (MODsc:A3) has decreased. Given the strong association between MODS and M for critically ill surgical patients, it is likely that the unchanged risk-adjusted M observed over time is due to the reduced magnitude of MODS.

**TELEMEDICINE TO A MOVING AMBULANCE IMPROVES OUTCOMES  
FOLLOWING TRAUMA SCENARIOS EXECUTED ON A HUMAN PATIENT  
SIMULATOR**

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**Invited Discussant:** Thomas E. Knuth, M.D., M.P.H.

**Objective:** To evaluate the impact of a Telemedicine (TM) link to a moving ambulance on outcome following trauma scenarios implemented using a Human Patient Simulator (HPS).

**Methods:** Prospective, double blind, IRB approved. Three trauma scenarios (blunt abdominal trauma, stab to epigastrium, closed head injury) were created for the HPS (Medical Education Technologies Inc.). Intermediate level EMT's (n=20) managed the HPS, in a moving ambulance, through each scenario. In the TM group, physicians (n=12) provided continuous consultation. In the non-TM group, EMT's communicated with medical control by radio, per standard protocol. We tabulated the fraction of 13 key signs and 5 pathologic processes (hemorrhage and tension pneumothorax (TPtx); hemorrhage and pericardial tamponade (TAMP); impending herniation) that were identified, as well as 12 key interventions that were performed. We also recorded the lowest SaO<sub>2</sub> (%) and systolic BP (mmHg), and the highest HR for each scenario. Due to non-normality, data were compared using the Wilcoxon rank sum test.

**Results:** Data are expressed as mean ± sem. \* p<0.003; + p<0.001

	TM *	Non-TM *		TM +	Non-TM +
<b>Signs</b>	.96 ± 0.01	.79 ± 0.05	<b>Low SaO<sub>2</sub></b>	84 ± 0.7	78 ± 0
<b>Processes</b>	.98 ± 0.02	.75 ± 0.05	<b>High HR</b>	144 ± 0.9	159 ± 0.5
<b>Interventions</b>	.92 ± 0.02	.49 ± 0.03	<b>Low SBP</b>	70 ± 1	53 ± 1

In 22 out of 24 TM scenarios with TPtx, or TAMP, EMT's were successfully guided through needle decompression procedures with subsequent normalization of the vital signs presented above. No decompression procedures were performed in the non-TM group.

**Conclusion:** Telemedicine to a moving ambulance improved the recognition and treatment of key signs and processes in a HPS model of trauma, with a corresponding improvement in physiologic state. Further, procedurally naïve EMT's were able to perform needle thoracostomy and pericardiocentesis with telemedicine guidance.

Session I

Paper 8 10:30AM

**POSTINJURY LIFE-THREATENING COAGULOPATHY: IS 1:1 THE ANSWER?**

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**Invited Discussant:** John B. Holcomb, M.D.

**Objective:** Recent military experience suggests that immediate 1:1 PRBC: FFP for casualties requiring > 10 units PRBC / 24hrs reduces mortality, but no clinical trials exist to address this issue. Consequently, we reviewed our massive transfusion practices over an 8 year period to test the hypothesis that 1:1 PRBC: FFP within the first 6 hours reduces life threatening coagulopathy.

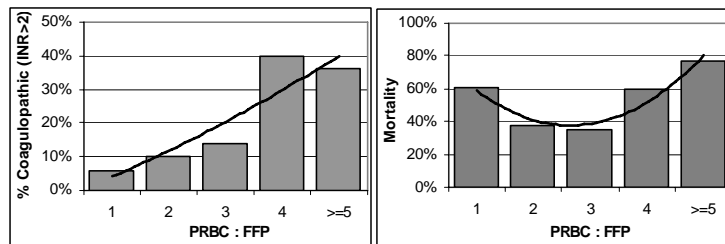
**Methods:** We queried our Level I trauma center's prospective registry from 1999-2006 for patients undergoing massive transfusion. Logistic regression (LR) was used to evaluate the independent effect of PRBC:FFP in 140 patients who received > 5 u PRBC on: 1) Coagulopathy (INR>2@6hrs), controlling for our previously described risk factors predictive of coagulopathy, as well as PRBC, FFP, and platelet administration 2) Death (controlling for all variables plus age, crystalloids/24hrs ,INR>2 @6hrs). Data are expressed as mean ± SEM

**Results:** Over 80% of the RBC transfusions were completed in the first 6 hrs: (PRBC: 18.9±0.9, 0-6hrs, 4.5± 0.7, 7-24 hrs), Median PRBC: FFP was 3, range 1-23. INR>2.0 @6hrs occurred in 24(16%); 92%died. LR showed PRBC: FFP was positively and independently associated with INR (beta=0.335±0.133; p=0.01, OR=1.4, 95% confidence interval 1.1-1.8.), when

adjusted for SBP, ISS, temperature, and pH. Regarding mortality, LR showed a U-shaped association (quadratic term estimate

0.2567±0.0838, p>0.0043)

**Conclusion:** While our data suggest that 1:1 PRBC: FFP reduced coagulopathy, this did not translate into a survival benefit. Our findings indicate that the relationship between coagulopathy and mortality is more complex, and further clinical investigation is necessary prior to recommending routine 1:1 in the exsanguinating trauma patient.





## DEEP VEIN THROMBOSIS SURVEILLANCE PATTERNS IN THE NATIONAL TRAUMA DATA BANK (NTDB): THE MORE WE LOOK, THE MORE WE FIND

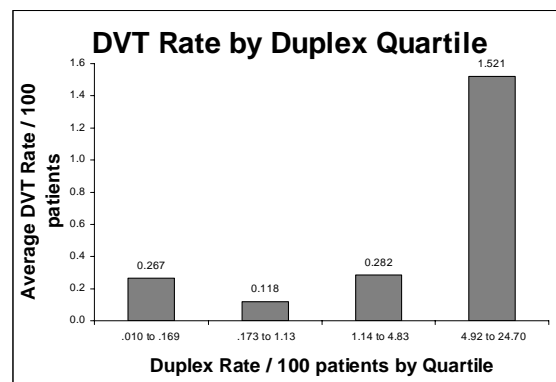
Charles Pierce MPH, Medical Student, Elliott R Haut MD, Sheri Kardooni MPH, Medical Student, David Chang MPH MBA PhD, David T Efron MD, Adil Haider MD MPH, Peter J Pronovost MD PhD, Edward E Cornwell III MD\*, The Johns Hopkins University School of Medicine, Baltimore, MD

**Invited Discussant:** George Velmahos, M.D., Ph.D.

**Background:** Deep vein thrombosis (DVT) has been identified as a marker of quality of care by various governmental and consumer groups. However, the lack of standardized DVT surveillance systems across trauma centers may introduce bias in the rates of DVT reported. We hypothesize that trauma centers with higher rates of duplex ultrasound screening detect more DVTs and subsequently report higher DVT rates to the NTDB.

**Methods:** We queried the NTDB version 6.1 and calculated duplex ultrasound rates and DVT rates per trauma center. We examined the relationship between the number of duplex ultrasounds performed and the number of DVTs reported per hospital. In order to account for variability in data reporting, we excluded hospitals that did not report performing any ultrasounds as well as hospitals that did not report any complications. Of the 700 facilities in the NTDB, 147 met these criteria (21%), accounting for 578,252 patients (39% of the total patients in the dataset). A simple linear regression was used to describe the association between ultrasound and DVT rates among hospitals.

**Results:** For every 1% increase in ultrasound rate there is a 0.14% increase in DVT rate reported (95% CI: 0.121-0.158). After separating the hospitals



into quartiles by duplex rate, the DVT rate in the highest quartile was 7-fold higher than the average combined DVT rate in the first three quartiles (1.52% vs. 0.22%,  $p < .0001$ ).

**Conclusions:** More aggressive screening procedures may be associated with higher DVT rates. Trauma centers that screen more and report higher DVT rates may be falsely labeled as having decreased quality of care. Using DVT rate alone as an independent quality measure should be reevaluated due to the potential for surveillance bias.

## NEW ALGORITHM FOR NON-OPERATIVE MANAGEMENT OF BLUNT SPLENIC TRAUMA LEADS TO ZERO FAILURE RATES

DK Gray MD, D Ouellette MD, W Michalski BSc, J Williamson , R Malthaner MD, M Girotti MD\*, NG Parry MD, University of Western Ontario and London Health Sciences Centre, London, Ontario, Canada

**Invited Discussant:** Andrew B. Peitzman, M.D.

**Background:** We have found that splenic pseudoaneurysms (SPA) develop in 4.8 days following blunt splenic injury (BSI) and are the cause of delayed splenic rupture. Splenic arterial embolization (SAE) is a viable method to achieve successful rates of nonoperative management (NOM) in BSI. Our purpose was to study the outcome of our “new” algorithm for BSI management. Our hypothesis was that with identification of SPA’s by repeat CT scan within 48 hours and the use of SAE to embolize the SPA, failure rates of NOM would decrease without negatively affecting mortality and hospital length of stay (LOS).

**Methods:** A retrospective cohort analysis was performed on all consecutive adult trauma patients with BSI admitted to a Level One Trauma Centre from 1995-2006. Since 2000, follow-up CT scans were performed within 48 hours and SAE was implemented. We evaluated 2 cohorts (1995-00 – early; 2000-06 – late) with failure rates of NOM as our primary outcome. Secondary outcomes were mortality rates and LOS.

**Results:** Five hundred and twenty seven patients (early – 159 patients vs late - 368 patients) with BSI were identified.

Splenic grades did not differ between groups. Median hospital LOS was reduced in the late cohort (7 vs 8 days;  $p=0.047$ ) while hospital mortality rates were not different.

Variable (n, %)	Early Cohort	Late Cohort	p-value
<b>ISS</b>	36	29	< 0.001
<b>SAE</b>	0 (0%)	34 (9.2%)	< 0.001
<b>NOM</b>	82 (52%)	259 (70.4%)	< 0.001
<b>Failure Rate</b>	10 (6%)	0 (0%)	< 0.001

**Conclusion:** Our results show that repeat CT within 48 hrs following admission and the use of SAE for those spleens which demonstrate splenic pseudoaneurysms has decreased our splenic failure rate to zero in the last 7 years regardless of grade. LOS was decreased and mortality did not change with this new protocol. Our success has led to a significant increase in non-operatively managed spleens in our centre.

## TEMPORARY ABDOMINAL CLOSURE TECHNIQUES: A PROSPECTIVE RANDOMIZED TRIAL

Tiffany K. Bee MD, Martin A. Croce MD\*, Louis J. Magnotti MD, Ben Zarzaur MD, George Maish MD, Gayle Minard MD\*, Timothy C. Fabian MD\*, University of Tennessee Health Science Center, Memphis, TN

**Invited Discussant:** Glen Tinkoff, M.D.

**Objective:** The options for abdominal coverage after damage control laparotomy or abdominal compartment syndrome (ACS) vary by institution, surgeon preference, and type of patient. Some advocate polyglactin mesh (MESH), others favor vacuum assisted closure (VAC). We performed a single institution prospective randomized trial comparing morbidity and mortality differences between MESH and VAC.

**Methods:** Patients expected to survive and requiring open abdomen management were prospectively randomized to either MESH or VAC. After randomization an enteral feeding tube was inserted and the closure device placed. VAC patients returned to the operating room every 3 days for a total of 3 changes at which time polyglactin mesh was placed if closure was not possible. The MESH group had twice daily assessments for the possibility of bedside mesh cinching and closure. Both groups underwent STSG when granulation tissue was evident, if delayed primary closure was not possible.

**Results:** 50 patients were randomized. Both cohorts were matched for ISS, gender, blunt/penetrating/ACS and age. Two patients in each group died within 7 days and were excluded. The table illustrates the outcomes:

Group	N	Delayed 1° Closure	Secondary Closure	Dead >7days	Enterocutaneous Fistula	Abdominal Abscess
VAC	27	9(33%)	7(26%)	6(22%)	5(19%)	12(44%)
MESH	19	5(26%)	4(21%)	4(21%)	1(5%)	10(53%)

All VAC fistulas were related to feeding tubes; the MESH fistula followed a retroperitoneal colon leak remote from the mesh.

**Conclusions:** MESH and VAC are both useful methods for abdominal coverage, and are equally likely to produce delayed primary closure. The fistula rate for VAC is most likely due to continued bowel manipulation with VAC changes with a feeding tube in place – enteral feeds should be administered via nasojejun tube. Neither method precludes secondary abdominal wall reconstruction.

## CT GRADING SYSTEMS POORLY PREDICT THE NEED FOR INTERVENTION AFTER SPLEEN AND LIVER INJURIES

Stephen M. Cohn MD\*, Jorge Arango MD, Daniel L. Dent MD, Peter P. Lopez, MD, Sandra Alexander, BS, Rachele Jonas RN, Lindsay L. Waite MS, Michael G. Corneille MD, Ronald M. Stewart MD\* and John G. Myers MD University of Texas Health Science Center, San Antonio, TX

**Invited Discussant:** Carlos V.R. Brown, M.D.

**Objective:** CT grading systems are often used to forecast the need for interventions after solid organ injuries. We compared the ability of various CT grading methodologies to predict the need for intervention.

**Methods:** Abdominopelvic CT's of 300 patients with spleen and/or liver injuries were evaluated by 5 trauma faculty blinded to outcomes (each reviewed 150 CTs). Studies were graded by AAST, Thompson-splenic injury<sup>1</sup> and McLean-liver injury<sup>2</sup> criteria. Need for operative or angiographic management was determined by chart review. AUC by ROC curve was used to describe the correlation between CT grade and need for intervention. Kappa statistic (K) was used to determine inter-rater variability.

**Results:** *AAST Spleen:* AUC=0.82(0.73-0.90), K=0.45(0.31-0.58); *Thompson:* AUC=0.82(0.74-0.91), K=0.54(0.39-.71); *AAST Liver:* AUC 0.72(0.58-0.87), K=0.44(0.26-0.62); *MacLean:* AUC=0.79(0.68-0.90), K=0.57(0.35-0.75). Values for AUC and kappa are means (95% CI range over all raters). There were no significant differences in AUC between grading methodologies, and kappa statistics appeared similar. *Table: AAST= Grade 1-2 vs. 3-5 as predictive of surgery/embolization; Values are means (range over all raters).*

	<b>Sensitivity</b>	<b>Specificity</b>
<b><u>AAST</u> spleen</b>	0.81 (0.67-0.92)	0.64 (0.49-0.69)
<b>Thompson spleen</b>	0.75 (0.62-0.92)	0.77 (0.69-0.90)
<b><u>AAST</u> liver</b>	0.60 (0.25-0.88)	0.62 (0.53-0.77)
<b>MacLean liver</b>	0.62 (0.25-1)	0.77 (0.59-0.84)

**Conclusions:** Current anatomic CT grading systems do not facilitate accurate prediction of the need for operation or embolization. There is considerable inconsistency of interpretation of CT scans even by experienced trauma surgeons. 1. *Thompson et al, J Trauma* 2006. 2. *MacLean et al, Emerg Radiol*, 2005.

## IMMUNOLOGIC INTEGRITY AFTER SPLENIC EMBOLIZATION FOR TRAUMA

Mbaga S. Walusimbi, MD, Kathleen M. Dominguez, MD, Elizabeth P. Tran, MD, Jean M. Sands, RN, BSN, Akpofure P. Ekeh, MD\*, Jonathan M. Saxe, MD\*, Randy J. Woods, MD, Mary C. McCarthy, MD\* Wright State University Boonshoft School of Medicine, Dayton, OH

**Invited Discussant:** James M. Haan, M.D.

**Objective:** The immunologic function of the spleen after successful embolization is not known; hence, some institutions practice routine immunization against encapsulated bacteria—*S. pneumoniae*, *H. influenzae* and *N. meningitidis*. We evaluated immunologic function after embolization and compared this to patients who had undergone splenectomy and to controls with a history of blunt trauma but no splenic injury.

**Methods:** Patients that had undergone splenic embolization (SE) and splenectomy (S) were recruited from the Trauma Registry at Miami Valley Hospital, a level I Trauma Center. A third group of trauma patients with no splenic injury (NS) served as a control. Total T and B-lymphocyte counts, serum complement, C3 and C4, and properdin levels were measured from blood samples of the study patients. Embolized patients underwent scintigraphy to evaluate radionuclide uptake of the spleen.

**Results:** There were no significant differences among the groups in the mean total T-lymphocyte count ( $p = 0.6$ ), no differences in serum complement levels, C3 and C4, ( $p = 0.5$  and  $0.2$ , respectively) and no difference in properdin levels ( $p = 0.2$ ). There were no significant differences in the mean B-lymphocyte counts between the embolization and control groups ( $p = 0.5$ ). However, mean B-lymphocyte counts were significantly higher in the splenectomy group than in the control group ( $p = 0.0017$ ), and in the embolization group ( $p = 0.0011$ ).

Patients (n)	Mean Total T-lymphocytes (cell/mm <sup>3</sup> )	Mean Total B-lymphocytes (cells/mm <sup>3</sup> )	Mean Complement C3 (mg/dl)	Mean Complement C4 (mg/dl)	Mean Properdin (mg/dl)
S (20)	1737.70	614.40	144.81	31.95	37.95
SE (11)	1525.09	238.27	140.27	32.27	35.82
NS (20)	1537.89	292.89	153.95	37.65	41.95

Splenic scintigraphy revealed in splenic tissue in all SE patients.

**Conclusion:** Splenic embolization does not impair the measured immunologic parameters. Therefore, routine vaccination may be unnecessary.

## EVOLUTION OF BLUNT SPLENIC INJURY: THE ROLE OF OUTPATIENT CT SCANNING

Stephanie A. Savage, MD, Ben L. Zarzaur, Jr., MD, Louis J. Magnotti, MD, Jordan A. Weinberg, MD, Tiffany K. Bee, MD, Timothy C. Fabian, MD\*, Martin A. Croce, MD\*, Department of Surgery, University of Tennessee Health Science Center, Memphis, TN, Department of Surgery, University of Alabama, Birmingham, AL

**Invited Discussant:** David A. Spain, M.D.

**Objective:** Non-operative management of blunt splenic injury (BSI) has become the standard of care for hemodynamically stable patients. Successful non-operative management raises two related questions: 1) what is the time course for splenic healing and 2) when may patients safely return to usual activities? There is little evidence to guide surgeon recommendations regarding return to usual activities. Our hypothesis was that time to healing is related to severity of BSI.

**Methods:** The trauma registry at a Level I trauma center was queried for patients diagnosed with a BSI managed non-operatively between 2002 and 2005, and survived at least one year after BSI. Follow-up abdominal CT scans were reviewed with attention to progression to healing of BSI. Kaplan-Meier curves were compared for mild (AAST Grade 1-2) and severe (Grade 3-5) BSI.

**Results:** 419 [104 Grade 1 (25%); 157 Grade 2 (37%); 98 Grade 3 (23%); 44 Grade 4 (11%); 16 Grade 5 (4%)] patients with a BSI were eligible for analysis. 36 patients had documented healing as inpatients. 64 out of 383 patients discharged with BSI had outpatient CT scans. 6 had worsening of BSI as outpatients and 2 (1 Mild BSI and 1 Severe BSI) required intervention (2 splenectomies). 19 were followed to complete healing. Mild BSI had faster mean time to healing compared to severe BSI (31 vs 49 days  $p=0.007$ ). The

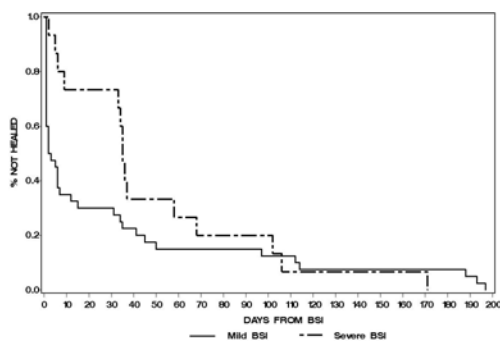


figure illustrates the time to resolution of BSI. Most healing occurred within 2 months, but approximately 20% of each group were not healed after 3 months.

**Conclusion:** While mild BSIs have faster early healing than severe BSIs, nearly 10% of all the BSI followed as outpatients worsened. 20% were not healed after 3 months. Close

observation of patients with BSI should continue until healing can be confirmed.

## EMERGENCY DEPARTMENT THORACOTOMY: STILL USEFUL AFTER ABDOMINAL EXSANGUINATION?

Mark J. Seamon MD, Abhijit S. Pathak MD\*, Kevin M. Bradley MD, Carol A. Fisher BA, John Gaughan PhD, Heather Kulp RN MPH, Paola G. Pieri MD, Thomas A. Santora MD\*, Amy J. Goldberg MD\*, Temple University Hospital, Philadelphia, PA

**Invited Discussant:** Rao R. Ivatury, M.D.

**Objective:** It is widely believed that traumatic arrest from penetrating abdominal injury (AB) is lethal and that emergency department thoracotomy (EDT) in this circumstance is futile. Recent investigations at our Level I urban trauma center suggest that observed salvage rates from penetrating chest injuries (CT) are related to cardiac and hemodynamic profiles at the time of presentation. We sought to extend these observations to penetrating traumatic abdominal injuries and to determine whether location of torso injury should be a determinant for performing EDT.

**Methods:** A retrospective review of all patients (2000 to 2006) who underwent EDT for penetrating torso injuries in an urban trauma center revealed 227 patients. All EDTs were performed for patients who presented in traumatic arrest or clinically deteriorated. Patients were sorted by primary injury location (CT vs AB) and compared with respect to clinical characteristics and survival until discharge.

**Results:** The 227 patients were comprised of 177 CT and 50 AB injuries. While no

difference (CT vs. AB) was detected in injury mechanism or pre-hospital time, patients in the AB group had more favorable cardiac rhythms,

	Cardiac/Thoracic (n=177)	Abdominal (n=50)	<i>p</i>
Mechanism (GSW)	158/177 (89.3%)	49/50 (98.0%)	0.085
Pre-hospital time (min.)	20.1 ± 8.9	21.2 ± 9.8	0.451
PEA or Sinus Rhythms	91/177 (51.4%)	37/50 (74.0%)	0.006
ED Vital Signs	39/177 (22.0%)	21/50 (42.0%)	0.007
ED Signs of Life	101/177 (57.1%)	39/50 (78.0%)	0.008
Survival Until Discharge	18/177 (10.2%)	8/50 (16.0%)	0.313

vital signs, and signs of life. Ultimately, 10% of CT patients and 16% of AB patients survived, neurologically intact, until hospital discharge.

**Conclusions:** This study demonstrates that primary penetrating injury location may not be as important predictor of EDT outcome as previously described. Physiologic parameters such as cardiac rhythm, vital signs, or signs of life may be more predictive of survival.

Thus, EDT should be aggressively utilized for patients in traumatic arrest due to any penetrating torso injury, regardless of primary injury location.

**A DECADE WITH TEMPORARY INTRAVASCULAR SHUNTS FOR TRAUMA. A BRIDGE INTO THE 21ST CENTURY**

Anuradha Subramanian, MD, Gary Vercruyse, MD, Amy Wyrzykowski, MD, Christopher Dente, MD, Grace Rozycki, MD\*, David V. Feliciano, MD\*, Emory University / Grady Memorial Hospital, Atlanta, GA

**Invited Discussant:** Donald H. Jenkins, M.D.

**Objective:** A 10 year review of temporary intravascular shunts at a regional trauma center.

**Methods:** Retrospective chart review of all patients treated with temporary intravascular shunts (TIVS) from 1/1/97 – 1/1/07.

**Results:** 786 patients were treated for vascular injuries. 67 (9%) had a total of 101 (72 arterial, 29 venous) TIVS placed to facilitate damage control or to allow for reconstruction of Gustilo IIIC fractures or limb replantation. 7 patients who, on trauma day 0, died or had an extremity which was deemed unsalvageable were excluded. Of 60 patients who met inclusion criteria, 7 died from TBI (3%), MOF (3%), sepsis (2%), deceleration of care (2%), and loss of airway (2%), which was deemed preventable.

Indications for Shunts						
			Damage Control			
	Gustilo IIIC Fractures	Limb Replant	Truncal	Extremity	All Damage Control	Total
# Pts	23	1	6	30	36	60
Mean base deficit	7 (±4.5)	8	14 (±8.8)	14 (±9.0)	14 (±8.4)	11 (±7.9)
Mean PRBC (units)	8 (±4.4)	12 (±9.2)	26 (±17.8)	12 (±9.0)	14 (±11.9)	12 (±10.0)
Fasciotomy rate	74%	100%	67%	90%	86%	82%
Mean shunt time (hrs)	13 (±2)	6	26 (±16)	24 (±16)	24 (±16)	24 (±16)
Amputation rate	13.0%	0%	33.3%	20.0%	22.2%	18%
Shunt thrombosis rate	4%	0%	33.3%	0%	5.6%	5%
Survival rate	96%	100%	67%	87%	83.3%	88%
# Argyle shunts	24	2	4	26	30	56
# Chest tube shunts	5	0	2	7	9	14
# Pruitt-Inahara shunts	6	0	1	12	13	19

**Conclusions:** (1) TIVS have a shunt thrombosis rate of 5%, amputation rate of 18%, overall survival of 88%, and combination limb/patient survival rate of 73%. (2) TIVS have an established role primarily in patients requiring either “damage control” for exsanguination or temporary vascular conduits during stabilization of Gustilo IIIC fractures. (3) Truncal injuries are associated with the highest mortality likely due to accompanying multisystem trauma.



**A DECADE OF “DONATION AFTER CARDIAC DEATH”: EXPANDING  
ORGAN DONATION OPTIONS AND AVAILABILITY OF TRANSPLANTABLE  
ORGANS**

Patrick K. Kim MD, Stacey L. Doll MPA, C. William Hanson MD, Richard D. Hasz MFS,  
Patrick M. Reilly MD\*, C. William Schwab MD\*, University of Pennsylvania School of  
Medicine and Gift of Life Donor Program, Philadelphia, PA

**Invited Discussant:** Ali Salim, M.D.

**Introduction:** The waiting list for organ transplantation is a significant problem. Most cadaveric organs arise from donation after brain death (DBD). Donation after cardiac death (DCD) would increase the donor pool but is not routinely performed. We hypothesized that (1) institutional commitment to DCD and collaboration with an Organ Procurement Organization (OPO) expands the availability of organs for donation, and (2) DCD has an acceptable yield of transplantable organs versus DBD.

**Methods:** Our university hospital first performed DCD in 1996 and created a DCD policy in 1998. The OPO and critical care staff met regularly for educational and process improvement purposes. We reviewed DBDs and DCDs from 1/1996 to 12/2006, comparing donor cause of death and subsequent organ recovery and transplantation. DCDs were categorized as controlled or uncontrolled, based on whether cardiac arrest was anticipated.

**Results:** There were 173 DBD and 52 DCD patients (Table). DCD comprised 23.1% of donors, 16.5% of organs recovered, and 14.6% of organs transplanted, totalling 90 kidneys, 18 livers, and 2 pancreati. DBD yielded the greatest number of organs per donor, followed by controlled DCD and uncontrolled DCD.

#p <0.05 vs DBD	DCD			DBD	Total
	controlled	uncontrolled	DCD total		
<b>Cause of death</b>					
Traumatic brain injury	22	5	27	80	107
Cerebrovascular/stroke	10	2	12	75	87
Anoxia	10	1	11	17	28
Other	1	1	2	1	3
<b>Donors</b>	43	9	<b>52</b>	173	225
<b>Organs recovered</b>	120	19	<b>139</b>	702	841
<b>Organs recovered/donor</b>	2.79#	2.11#	<b>2.67#</b>	4.06	3.74
<b>Organs transplanted</b>	95	15	<b>110</b>	643	753
<b>Organs transplanted/donor</b>	2.21#	1.67#	<b>2.12#</b>	3.72	3.35

**Conclusions:** DCD was successfully implemented after institutional commitment and OPO collaboration. DCD increased availability of transplantable organs. The yield of transplantable organs from DCD is lower than that from DBD, especially when DCD is uncontrolled. While DBD continues to be the primary route for organ donation, DCD is a viable alternative for organ donation when brain death is not anticipated.

**DEFERRED PRIMARY ANASTOMOSIS IMPROVES OUTCOME IN PATIENTS WITH SEVERE INTRA-ABDOMINAL SEPSIS**

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**Invited Discussant:** Louis R. Pizano, M.D.

**Background:** Damage control (DC) and staged laparotomies have been advocated as viable management options for patients with severe intra abdominal sepsis (IAS). The traditional approach is to perform a bowel diversion (enterostomy or colostomy). Our group has implemented a protocol for DC/staged laparotomy followed by deferred primary anastomosis (DPA) which is performed when pre-established criteria for sepsis have been met. DPA patients undergo one additional laparotomy followed by abdominal closure.

**Objective:** To compare DC/DPA versus standard DC and diversion-ostomy in a group of patients with severe IAS.

**Methods:** We performed a historical control matched comparison between patients with DPA (n=34) versus a group of patients (n=78) submitted to entero/colostomy. Patients were matched by age and gender.

**Results:** See table

	<b>DC+ DPA (n=34)</b>	<b>Diversion (n=78)</b>	<b>p</b>
Age, mean ± SD, years	57.2 ± 21.6	56±22	0.79
Male, %	67.7	64.5	0.71
Relaparatomies, mean±SD	3.8 ± 2.3	4.2 ± 3	0.9
APACHE II, mean SD	16.1± 7	14.9± 5.3	0.09
MODS, mean ± SD	4.5 ± 2.3	3.5 ± 4.1	0.09
Perforation/Postop complications %	80.6	75.6	0.6
Post -Trauma IAS %	19.4	24.4	0.57
UCI stay, mean±SD, days	17.5 ± 9.8	17.5±9.6	0.96
Length stay, mean±SD days	27.5 ± 18.7	26.7 ± 18.2	0.82
Vent days, mean±SD	9.2 ±7.3	9 ± 9	0.08
Shock	74.2	60.3	0.17
<b>ARDS</b>	<b>13</b>	<b>31</b>	<b>0.05</b>
Fistulas	8.8	23.1	0.07
Mortality, %	11.8	16.7	0.5
<b>Ostomies, %</b>	<b>14.7</b>	<b>100</b>	<b>&lt;0.01</b>

**Conclusions:** In patients with IAS and comparable APACHE and MODS, a protocol for DPA is safe and it is associated with reduced pulmonary morbidity, and high rate of success defined as reduced number of ostomies, with no change in mortality or hospital resource utilization. DPA is a viable option that may reduce long term morbidity associated to the management of enterostomies.

**TEAM-ORIENTED TRAINING FOR DAMAGE CONTROL SURGERY IN  
RURAL TRAUMA: A NEW PARADIGM**

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**Invited Discussant:** Ari K. Leppaniemi, M.D.

**Objective:** The unique geography of Norway has led to a national initiative to train teams from rural hospitals in the principles of damage control surgery using an innovative team-oriented approach based on Crew Resource Management principles. Our aim was to evaluate this approach and its impact on trauma care in rural hospitals across Norway.

**Methods:** 38 teams from 21 hospitals participated in 10 courses (2003-2006), where providers from the same hospital trained together as a team. Each course consisted of two interactive scenario-based lecture modules and two operative sessions on live porcine models that emphasize communication, collaboration and team-based problem solving. Extraperitoneal packing for bleeding pelvic fractures was taught on human cadavers. The data collection tool was a questionnaire filled at course completion (231 questionnaires analyzed, 74% of participants). In addition, a phone survey was conducted among chairs of surgery in participating hospitals to assess the implementation of course content.

**Results:** Teams consisted of surgeons (34%), OR nurses (35%) and anesthesiology staff (31%). Most participants (N=143, 62%) had used damage control previously, but four of every five reported suboptimal performance, mostly due to miscommunication (35%) and team leadership (29%) issues. Almost all course participants (N= 228, 99%) reported a dramatic increase in their proficiency with damage control techniques. There was a mean increase of 2.3 points in proficiency with extraperitoneal pelvic packing on a 5-step Likert scale, and a similar mean increase of 1.5 points with emergency thoracotomy. The team approach was perceived as vital by 218 (94%) of participants. The phone survey revealed 12 reported cases of lifesaving rural damage control operations by course graduates in the past 3 years, for an estimated cost of \$35,000 per life saved.

**Conclusions:** Teaching damage control surgery using a team-oriented approach is an innovative educational methodology specifically tailored to the needs of rural hospitals that manage low volumes of major trauma.

**GUT ISCHEMIA/REPERFUSION INDUCED ACUTE LUNG INJURY IS AN ALVEOLAR MACROPHAGE DEPENDENT EVENT**

Belchor Fontes MD, Luciana Borsoi Moraes, Medical Student, Abel Hiroshi F. Murakami MD CH, Nico Van Rooijen, Renato Sergio Poggetti CH\*, Riad Nain Younes MD CH, Ana Maria Cattani Heimbecker CH, Dario Biorolini MD, Free Univ. Medical Center, Amsterdam, The Netherlands and Hospital das Clínicas da Faculdade de Medicina da USP, Sao Paulo, Brazil

**Invited Discussant:** Rosemary A. Kozar, M.D., Ph.D.

**Objective:** Although the role of lung alveolar macrophage (AM) as a mediator of acute lung injury following lung ischemia/reperfusion (I/R) has been suggested in animal models, it has not been determined for acute lung injury (ALI) following intestinal I/R. Clodronate (*Cl<sub>2</sub>MBP*) (Roche Diagnostics GmbH, Mannheim, Germany), encapsulated in liposomes, has been shown to selectively eliminate tissue macrophages. The objective of this study was to determine the effect of AM elimination on ALI following intestinal I/R in rats.

**Methods:** Wistar male rats (n=90) were randomized into 3 groups: clodronate-liposomes (CLOD-LIP) group received intra-tracheal treatment with clodronate-liposomes; liposomes (LIP) group received intra-tracheal treatment with liposome, and non-treated (UNTREAT) group received no treatment. Twenty-four hours later each group animals were randomized into: intestinal ischemia/reperfusion (I/R) subgroup, subjected to 45min intestinal ischemia and 2hr reperfusion; laparotomy (LAP) subgroup was subjected to laparotomy; control (CTR) subgroup received no treatment. At the end of reperfusion, ALI (Evans blue dye [EBD] method) was quantitated in all the animals.

**Results:** ALI values are expressed as EBD lung leak ( $\mu\text{g EBD/g lung dry weight}$ ), and in the CLOD-LIP group were: I/R =  $32.59 \pm 12.74$ ; LAP =  $27.74 \pm 7.99$ ; CTR =  $33.52 \pm 10.17$ ; in the LIP group: I/R =  $58.02 \pm 18.04$ ; LAP =  $31.90 \pm 8.72$ ; CTR =  $27.17 \pm 11.48$ ; and in UNTREAT group: I/R =  $55.60 \pm 10.96$ ; LAP =  $35.99 \pm 6.89$ ; CTR =  $30.83 \pm 8.41$ . The statistical analysis showed that within each group, LAP values did not differ from CTR values, but either were lower ( $p < 0.001$ ) than I/R subgroup values in LIP and UNTREAT groups. CLOD-LIP I/R value was lower ( $p < 0.001$ ) than I/R values in LIP or UNTREAT groups.

**Conclusion:** These results indicate that I/R provokes ALI that is prevented by clodronate-liposomes treatment, and suggest that AM is essential for the occurrence of ALI induced by intestinal I/R in rats.

## VARIATION AT THE +896 POSITION IN THE TLR4 GENE DECREASES THE RISK ORGAN FAILURE AND SHOCK ASSOCIATED WITH POST-TRAUMA SEPSIS

S. Shalhub, MD, MPH, C.E. Junker, BS., S. Dissanaik, MD, G.E. O'Keefe\*, MD, MPH, Harborview Medical Center, University of Washington, Seattle, WA

**Invited Discussant:** Timothy R. Billiar, M.D.

**Objective:** Genetic variation undoubtedly contributes to complex disease risk and outcomes, such as post-traumatic sepsis. Sepsis after serious injury is often unpredictable in severity and occurrence. We previously identified and reported associations with inflammation-related gene polymorphisms (SNPs) and now study a new and larger cohort in effort to confirm or disprove previously identified associations.

**Methods:** We studied 247 Caucasian patients with post-traumatic sepsis surviving more than 48 hours after severe injury. Candidate SNPs were TNF- $\alpha$  G-308A, TLR4 A896G, IL-6 G-174C, and CD14 C-149T. We compared SNP genotypes between patients with uncomplicated and complicated sepsis (sepsis with organ failure or shock) by chi-square analysis and logistic regression.

**Results:** After adjustment for independent risk factors for complicated sepsis, carriage of the TLR4 +896 variant was associated with a lower risk of complicated sepsis compared to wild-type homozygotes (table). This association was primarily due to a lower incidence of complicated gram-negative sepsis among variant allele carriers (39%) compared to wild type allele carriers (64%). Among patients with gram-negative sepsis (n = 153), the variant allele was associated an approximate 3-fold reduced risk of complicated sepsis (OR 0.28, 95%CI 0.09-0.88, p = 0.029). Carriage of the TNF-a -308 variant was associated with 5-fold increased risk of complicated sepsis.

Factor	OR (95% CI)	P
Age	1.01 (1.00-1.03)	0.071
Sex (Male)	2.24 (1.25-3.99)	0.006
First Base Deficit	1.13 (1.05-1.21)	0.001
ISS	1.03 (1.00-1.07)	0.043
TLR4 +896 A	2.93 (1.08-7.91)	0.034
TNF-a -308 A	1.99 (1.02-3.87)	0.043

**Conclusions:** Variation in the TLR4 and TNF- $\alpha$  genes are associated with the severity of post-traumatic sepsis. Genetic variation in genes responsible for pathogen recognition and the subsequent innate immune response, in part, determine sepsis severity.

**SYSTEMIC UBIQUITIN RELEASE AFTER BLUNT TRAUMA AND BURNS:  
ASSOCIATION WITH INJURY SEVERITY, POST-TRAUMATIC  
COMPLICATIONS AND SURVIVAL**

M. Majetschak MD PhD, S. Zedler PhD, A. Hostmann MD, M. Patel MD, L. Busby BS, F. Habib MD, M. DeMoya MD, W. Ertel MD\*, E. Faist MD\*, F.U. Schade PhD, University Hospital Essen, Essen, Germany, University of Munich, Munich, Germany, and University of Miami Miller School of Medicine, Miami, FL

**Invited Discussant:** Marc G. Jeschke, M.D., Ph.D.

**Objective:** Recent data suggest that ubiquitin (Ub) is systemically released after trauma in patients, has pleiotropic effects on host defense mechanisms *in-vitro*, and that Ub administration significantly reduces fluid shifts into the tissue during inflammation *in-vivo*. Ub release after burns has not been studied and its association with injury severity and outcome after blunt trauma is unknown. Thus, it was the objective to determine if Ub serum levels depend on the injury severity and are associated with outcome in blunt trauma (T) and burned (B) patients.

**Methods:** Injury severity was assessed with the Injury Severity Score (ISS) in T and %burned total body surface area (%TBSA) in B. 132 T (ISS 27±1) and 38 B (%TBSA 41±3) were included (age>18y) and observed for development of sepsis/multiple organ failure (Yes/No) and survival during hospitalization. Controls: 20 volunteers (C). Ub serum levels (ng/mL) were determined on day0 (=admission, T n=124; B n=21),1 (T n=66; B n=28),3 (T n=63; B n=27),5 (T n=58; B n=25),7 (T n=26; B n=24) by ELISA. Statistics: t-test or ANOVA/Tuckey post-hoc correction for multiple comparisons (2-tailed p<0.05)

**Results:** Ub was significantly increased in T and B. Peak levels were detectable on day0 (C:63±8; T:354±18; B:858±97;p<0.05). Ub gradually cleared after T (day7:165±25; p<0.05) but remained elevated after B (day7:605±76). Day0 levels correlated positive with ISS or %TBSA (p<0.05). There were no differences between T with/w/o development of sepsis/MOF or survival. Ub levels were significantly lower during the observation period in B who developed sepsis/MOF (n=8; 416±38) and during days5-7 in B non-survivors (n=8; 416±33), as compared with B w/o sepsis/MOF development (746±44) or B survivors (742±76) who were matched for %TBSA.

**Conclusion:** Systemic Ub levels correlate with injury severity after T and B. The low Ub levels in B with development of sepsis/MOF in connection with its *in-vivo* effects on third spacing of fluids into the tissue suggest that Ub release is protective and that it could play an important role during the physiologic response to burn injury.

**PREVENTION OF HYPOXIA INDUCED NEURONAL APOPTOSIS THROUGH HISTONE DEACETYLASE INHIBITION**

Yongqing Li, MD, PhD, Baoling Liu, MD, Elizabeth Sailhamer, MD, Christian Shults, MD, George Velmahos, MD, PhD\*, Marc deMoya, MD, and Hasan B. Alam, MD\*, Massachusetts General Hospital, Boston, MA

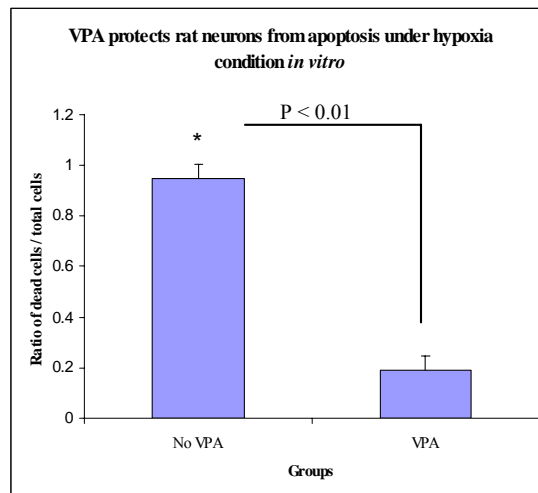
**Invited Discussant:** Michael A. West, M.D., Ph.D.

**Objective:** We have recently found that administration of valproic acid (VPA), a histone deacetylase (HDAC) inhibitor, enhances nuclear histone acetylation and improves survival following lethal hemorrhage in rats. In the present study, neurons were subjected to severe hypoxic condition *in vitro* to test whether VPA would prevent hypoxia-induced apoptosis.

**Methods:** Primary hippocampal and cortical cultures dissociated from E18 rat embryos were plated in quadruplicate at a density of  $2 \times 10^5$ /well in neurobasal medium supplemented with B-27 on glass cover-slips coated with poly-L-lysine. On the 10<sup>th</sup> day after plating, cells were incubated in a hypoxia chamber (0.5% O<sub>2</sub>, 10% CO<sub>2</sub>, 89.5% N<sub>2</sub>) at 37 °C for 16 h in the presence or absence of VPA (1 mM). The cells were then fixed, stained with anti-activated caspase-3 and anti-acetyl histone3 lysine 9 (Ac H3 K9) antibodies and visualized under confocal microscope. The caspase-3 positive cells were counted as apoptotic. Ratio of the apoptotic to total cells stained with 4',6-diamidino-2-phenylindole (DAPI) was determined. Numerical data were subjected to Student's *t*-test analysis.  $P < 0.05$  was considered statistically significant.

**Results:** Exposure of neurons to VPA prevented apoptotic cell death under hypoxic condition. In contrast, about 95% cells underwent apoptosis at the same level of hypoxia (Figure). VPA-treated cells had significantly stronger signal of Ac H3 K9, consistent with hyperacetylation of nuclear core histone H3.

**Conclusion:** VPA enhances acetylation of histone 3 at lysine 9, and protects rat neurons from hypoxia-induced apoptosis *in vitro*.



## INHIBITORY EFFECTS OF INTERLEUKIN-1 ON GROWTH HORMONE INDUCIBLE GENE EXPRESSION ARE MEDIATED BY NF- $\kappa$ B

Mark Buzzelli, MD, Tamer Ahmed, MD, Maithili Navaratnarajah, MS, Murali Nagarajan, MD, Margaret Shumate, MD, Robert Cooney, MD\*, Penn State University, Hershey, PA

**Invited Discussant:** David B. Hoyt, M.D.

**Background:** Following injury or infection, hepatic expression of GH-inducible genes like serine protease inhibitor (Spi 2.1) and insulin-like growth factor-I (IGF-I) are inhibited by inflammatory cytokines like IL-1, a phenomenon called hepatic GH resistance. Spi 2.1 is the rat homolog of  $\alpha$ 1-antitrypsin, an inhibitor of neutrophil elastase mediated tissue injury.

**Objective:** To determine whether the inhibitory effects of IL-1 on GH-inducible gene expression in cultured hepatocytes are mediated via the NF- $\kappa$ B signaling pathway.

**Methods:** First, I $\kappa$ B $\alpha$ S/A was shown to block IL-1 mediated activation of NF- $\kappa$ B. Then, CWSV1 hepatocytes were co-transfected with the Spi 2.1 (-1059 to +8) promoter construct and empty pcDNA3 vector or an I $\kappa$ B $\alpha$ S/A dominant negative vector. Cells were treated  $\pm$  IL-1 (10 ng/ml 24 h), then stimulated  $\pm$  GH (500 ng/ml for 4 h). Cell extracts were assayed for luciferase activity and protein, normalized and expressed as fold-induction. Data are means  $\pm$  SE (n=6/group). Statistical analysis of data are by ANOVA, then Neuman-Keuls.

**Results:** CWSV1 hepatocytes co-transfected with pcDNA3 demonstrate a 5-fold induction of Spi 2.1 promoter activity following GH stimulation that is significantly attenuated by

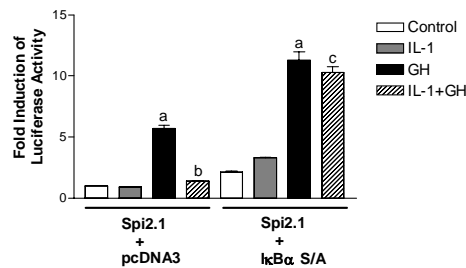
IL-1 (<sup>a</sup> p<0.001 vs. Control, IL-1, IL-

1+GH, <sup>b</sup> p<0.001 vs. GH). Co-

transfection with I $\kappa$ B $\alpha$ S/A increased basal Spi 2.1 activity and did not affect GH-inducible Spi 2.1 activity. However, the inhibitory effects of IL-1 were

prevented (<sup>a,c</sup> p<0.01 vs. Control, IL-1).

**Conclusions:** These findings suggest that signaling via the NF- $\kappa$ B pathway is responsible for the inhibitory effects of IL-1 on GH-inducible gene expression in CWSV1 hepatocytes.





**INJURY STIMULATES AN INNATE RESPIRATORY IGA IMMUNE RESPONSE IN HUMANS**

Kenneth A. Kudsk, MD\*, Joshua L. Hermsen, MD, Laurence Genton, MD, Lee Faucher, MD\*, F. Enrique Gomez, PhD, University of Wisconsin, Madison, WI

**Invited Discussant:** Ronald V. Maier, M.D.

**Introduction:** IgA is the specific immune anti-bacterial defense. Since pneumonia usually occurs 4 days after trauma, we studied early airway immune responses following injury.

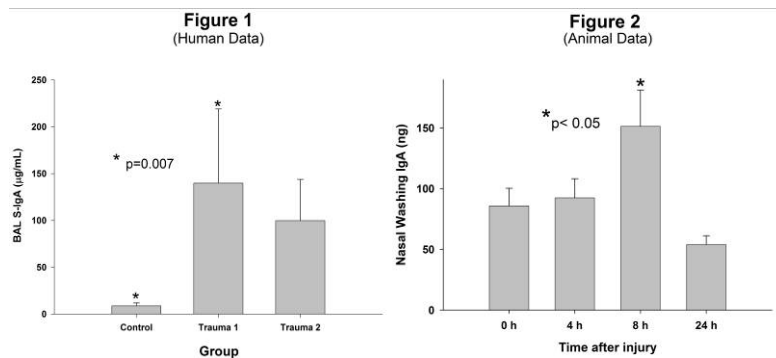
**Methods:** 9 severely injured, intubated (expected for  $\geq 5$  d) patients had tracheal & bilateral lung lavage (BAL) within 30 hr of injury (n=9) & 48 hrs later (n=8) with epithelial lining fluid (ELF) volume & IgA measured by urea dilution & ELISA, respectively. Controls were from 6 healthy elective surgical patients. Samples with highest IgA at each time are shown (low & mid level results are similar) & compared by Welch t-test. To verify human data, 30 male mice received no injury (time 0, n=7) or injury with abdominal + neck incisions and sacrificed for airway IgA at 4 (n=7), 8 (n=8) and 24 (n=8) hrs.

**Results:** Initial trauma IgA increased compared to control (Fig 1,  $p=0.007$ ), dropping slightly 48 hrs later ( $p=0.09$  vs control). ELF volume at 24 hr increased vs. control ( $p=0.14$  for high but  $p<0.05$  for mid & low). The second BAL IgA increased in 4/8, decreased in 3 & remained stable in 1. Mouse IgA (Fig 2) increased 8 hrs after stress ( $p<0.05$  vs. all other times) & normalized at 24 hrs.

**Conclusion:** A

previously unrecognized innate human airway mucosal immune response with increased IgA and ELF occurs after

severe injury and is reproducible experimentally. This accessible, quantifiable human response allows study of clinical strategies to reduce infections via mucosal immune therapies.



**RISK FACTORS FOR RELAPSE OF VENTILATOR-ASSOCIATED  
PNEUMONIA IN TRAUMA PATIENTS**

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Ashkan Attaran B.S., George Tannous, B.S., Jay A Johannigman M.D.\*, University of  
Cincinnati, Cincinnati, OH

**Invited Discussant:** Preston R. Miller, M.D.

**Objective:** To define risk factors for VAP relapse and to determine the implications for initial therapy in the trauma patient population.

**Methods:** All trauma patients admitted to the surgical intensive care unit over a 48 month period with confirmed VAP recurrence were evaluated. Recurrent VAP was defined as a positive quantitative culture ( $\geq 10^4$  colony-forming units/mL in a bronchoalveolar lavage or protected catheter lavage specimen)  $\geq 4$  days after initiation of antibiotics for the primary episode. Recurrence with at least one of the initial causative pathogens was defined as relapse, while recurrence with a different organism(s) was defined as superinfection. Initial causal pathogen, APACHE II scores, Injury Severity Scores (ISS), Glasgow Coma Scores (GCS), age, and duration of hospital stay prior to diagnosis were analyzed in univariate and multivariate regression models.

**Results:** 61 patients met the criteria of recurrent VAP. Of these 61 recurrences, 21 (34%) were relapses and 40 (66%) were superinfections. APACHE II score, ISS, and GCS were not associated with VAP relapse by univariate or multivariate regression analyses. Patients who relapsed had primary VAP involving nonfermenting gram-negative bacilli (NFGNB) (*Acinetobacter*, *Pseudomonas*, and *Stenotrophomonas* species) or methicillin-resistant *Staphylococcus aureus* (MRSA) more frequently than other organisms (62% vs 38%,  $p=0.002$ ). Primary VAP with NFGNB or MRSA were found to be significant predictors of VAP relapse when evaluated in separate multivariate logistic regression models that included age, duration of hospital stay, and each of the following collinear variables: APACHE II score (OR=11.4,  $p=0.05$ ), ISS (OR=6.0,  $p=0.009$ ), and GCS score (OR=6.0,  $p=0.005$ ).

**Conclusions:** In our study there was a high rate of VAP relapse associated with primary infection by NFGNB and MRSA. This suggests initial treatment failure. Trauma patients with primary VAP involving these organisms may benefit from modification of initial therapy or from increased surveillance for relapse.

## SUBTHRESHOLD QUANTITATIVE BRONCHO-ALVEOLAR LAVAGE: CLINICAL AND THERAPEUTIC IMPLICATIONS

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Karen Smalra, BS, C Todd Borchers, ACNP, Nancy Martin, BSN, Rao R Ivatury\*, MD, Medical  
College of Virginia, Virginia Commonwealth University, Richmond, VA

**Invited Discussant:** John T. Schulz, III, M.D.

**Background:** Quantitative Broncho-alveolar Lavage (qBAL) is utilized for accurate diagnosis of Ventilator Associated Pneumonia (VAP). The current study aims at defining the prevalence, outcomes and therapeutic implications of false negative (FN) qBAL.

**Methods:** Ventilated trauma, surgery, burn, and transplant patients suspected of VAP underwent bronchoscopic qBAL. VAP was defined as qBAL with  $>10^5$  CFU/ml. To identify FN, blood cultures drawn from 5 days before to 7 days after qBAL were analyzed. qBAL specimens growing  $<10^5$  CFU/ml with blood culture identifying the same organism, without any other source, were classified as FN.

**Results:** Over 36 months, 250 patients underwent 365 qBALs. 73 (20%) demonstrated 92 VAP organisms ( $>10^5$  CFU/ml). 14 (15%) of these were associated with bacteremia. 333 organisms grew at  $<10^5$  CFU/ml and 35 (10%) of these were associated with bacteremia (FN). The outcomes were as follows:

Outcomes	$<10^5$ CFU/ml (n=333)		$>10^5$ CFU/ml (VAP=92)	
	Blood +	Blood –	Blood +	Blood –
Ventilator (days)	17.0±1.8	16.5±1.2	8.2±1.3	15.7±1.7
ICU LOS (days)	42.1±5.6	37.7±2.6	21.2±4.0	34.8±3.4
Hosp. LOS (days)	54.7±5.9	51.0±3.3	27.6±5.0	48.1±5.0
% Mortality*	26%	14%	33%	17%

\* $p < 0.05$ ; CFU: Colony Forming Units; LOS: Length of stay; Mean  $\pm$  SEM

Bacteremia was associated with increased mortality in FN and VAP groups. 31/92 (33%) of VAPs were caused by 4 difficult to treat/eradicate organisms (MRSA, acinetobacter, enterobacter, and pseudomonas). 6/14 (43%) of bacteremias in VAP group and 21/35 (60%) in FN group were by these organisms.

**Conclusions:** Bacteremic invasive pulmonary infection increases mortality. 10% of qBALs may be FN for diagnosing invasive pulmonary infection, and 60% of these FNs are by difficult to treat/eradicate organisms. Isolation of these organisms in BAL, at any strength, should prompt consideration for antibiotic therapy.

**A DI-KETOPIPERAZINE FRAGMENT FROM HUMAN SERUM ALBUMIN  
MODULATES  
T- LYMPHOCYTE ACTIVATION.**

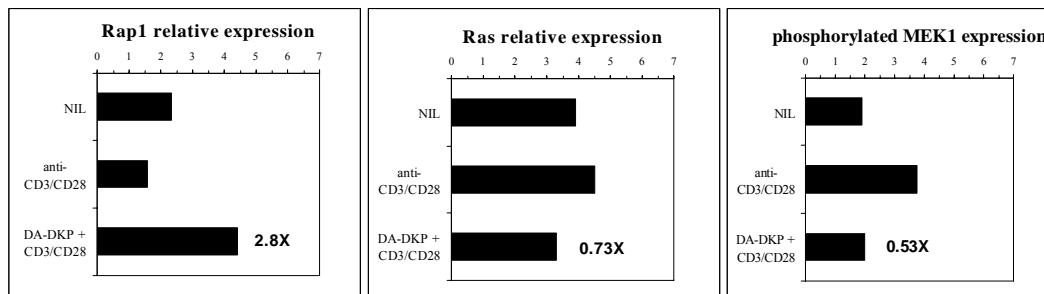
Richard Shimonkevitz PhD, Gregory Thomas BS, Danetta Sue Slone MD, Michael Craun MD\*,  
David Bar-Or MD, HealthONE Swedish Medical Center, Englewood, CO

**Invited Discussant:** Edwin A. Deitch, M.D.

**Objective:** An N-terminal fragment of human serum albumin, aspartate-alanine (DA)-diketo-piperazine (DKP) is generated by the consequences of inflammation *in vivo*, or alternatively, by heating albumin solution *in vitro* (*Crit Care Med* 2005 33:1638-41). We have previously shown DA-DKP present in commercial human serum albumin product intended for the treatment of shock, acute restoration of blood volume and hypo-albuminemia to be immunosuppressive *in vitro* (*Crit Care Med* 2006 34:1707-12). Here, we determined the molecular events responsible for DA-DKP inhibition of memory T-lymphocyte Interferon-gamma and Tumor Necrosis Factor-alpha production.

**Methods:** Human T-lymphocytes were activated via the T-cell receptor complex with anti-CD3/CD28 in the presence of DA-DKP relevant to commercial HSA preparations. Activation and transcription factors relevant to T-cell activation and cytokine production were analyzed by protein array, active protein pull-down blots and enzyme immuno-assay.

**Results:** With T-cell receptor stimulation, DA-DKP-induces in T-lymphocytes an over-expression of the GTPase RAP1 and decreased RAS and MEK1 activation. This, in turn, leads to decreased phosphorylated NF kappa-B, c-fos and c-jun levels (data will be presented) with the consequential effect of decreased T-lymphocyte cytokine production.



**Conclusions:** Human serum albumin can modulate the secondary immune response subsequent to its release of DA-DKP due to the events of trauma and inflammation.

**THE RELATIONSHIP OF PLASMA GLUCOSE AND GLYCOSYLATED HEMOGLOBIN A1C LEVELS AMONG NON-DIABETIC TRAUMA PATIENTS**

Tammy R Kopelman MD, Patrick J O'Neill PhD, MD, Shalini Kanneganti MD, Karole Davis MD, David Drachman PhD, Maricopa Medical Center, Phoenix, AZ, Sponsoring member: Richard Miller MD\*, Vanderbilt University Medical Center, Nashville, TN

**Invited Discussant:** Anthony A. Meyer, M.D., Ph.D.

**Objective:** Hyperglycemia (blood glucose  $\geq 110$  mg/dl) in trauma patients without a known history of diabetes mellitus (DM) is often attributed to the metabolic stress response of injury. We studied whether this hyperglycemia may actually indicate the presence of occult DM (ODM) as demonstrated by elevated glycosylated hemoglobin A<sub>1C</sub> (gHbA<sub>1C</sub>).

**Methods:** Following IRB approval, a prospective, sequential case series study of non-diabetic adult patients presenting to an urban Level I Trauma Center from 9/06- 2/07 was performed. In addition to basic demographics, all hyperglycemic patients had a measured gHbA<sub>1C</sub>. ODM was diagnosed when gHbA<sub>1C</sub>  $\geq 6\%$ .

**Results:** A total of 1039 trauma patients were screened with 192 (18%) noted to be hyperglycemic. Of these 192 patients, 22% (n=42) were found to have an elevated gHbA<sub>1C</sub>. Using logistic regression, being older (OR 1.01-1.07; p<0.004), having a higher BMI (OR 1.04-1.21; p<0.003), and being Native American (OR 1.34-19.29; p<0.017) were each identified as significant risk factors for elevated gHbA<sub>1C</sub> levels and the diagnosis of ODM. In contrast, the magnitude of observed hyperglycemia, gender, or other races were not shown to be significant risk factors for the presence of ODM.

**Conclusion:** Almost a quarter of non-diabetic trauma patients presenting with hyperglycemia were found to have elevated gHbA<sub>1C</sub> levels and ODM. The hyperglycemia seen in this patient population should not solely be attributed to the metabolic response to injury; wider ODM testing for both acute management strategies and long-term health benefits is warranted.

**RECOMBINANT ACTIVATED FACTOR VII USE IS ASSOCIATED WITH DECREASED MORTALITY IN COMBAT-RELATED CASUALTIES WITH SEVERE TRAUMA**

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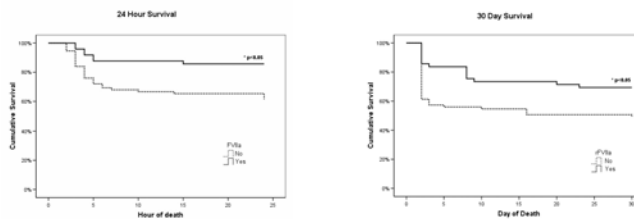
**Invited Discussant:** Thomas M. Scalea, M.D.

**Background:** The majority of patients with potentially survivable combat-related injuries die from hemorrhage. Recombinant activated factor VII (rFVIIa) is a pro-hemostatic agent that improves clot formation and decreases bleeding at the site of injury. Our objective was to determine if the use of rFVIIa decreased mortality in combat casualties with severe trauma who received massive transfusions and if its use was associated with increased severe thrombotic events.

**Methods:** Retrospective review of database of combat casualty patients with severe trauma and massive transfusion admitted to one combat support hospital in Baghdad, Iraq between December 2003 and October 2005. Admission vitals and labs, Injury Severity Score (ISS), 24 hour and 30 day mortality, and severe thrombotic events were compared between patients who did and did not receive rFVIIa.

**Results:** For the 124 patients in this study, 49 patients received rFVIIa + and 75 did not rFVIIa -. ISS was equal,  $25 \pm 9$  vs.  $26 \pm 10$ , for rFVIIa + and rFVIIa - patients respectively, ( $p=0.6$ ). All admission vitals and labs were equal between rFVIIa+ and rFVIIa- groups except for SBP (mmHg)  $105 \pm 33$  and  $92 \pm 28$ ,  $p=0.02$  and temperature ( $^{\circ}F$ )  $96.3 \pm 2.1$  and  $95.2 \pm 2.4$ ,  $p=0.03$ , respectively. When comparing rFVIIa (+) to rFVIIa (-) patients, 24 hour mortality was 7/49 (14%) and 26/75 (35%), ( $p=0.01$ ) and 30 day mortality was 15/49 (31%) and 38/75 (51%), ( $p=0.03$ ). Death from hemorrhage was 8/14 (57%) for rFVIIa + patients and 29/37 (78%) for rFVIIa - patients, ( $p=0.12$ ). The incidence of severe thrombotic events was equal in both groups.

**Conclusion:** In this retrospective study, the use of rFVIIa was associated with decreased death from hemorrhage for severely injured combat casualties requiring massive transfusion and was not associated with increased risk of severe thrombotic events.



**OBTAINING ACCURATE GLUCOSE VALUES FROM POINT-OF-CARE  
GLUCOMETERS IN ANEMIC INTENSIVE CARE UNIT PATIENTS**

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**Invited Discussant:** Rajan Gupta, M.D.

**Objective:** Previous studies have shown that tight glucose control in the intensive care unit (ICU) is associated with improved patient mortality and decreased morbidity. Likewise restrictive transfusion strategies have lowered Hgb levels in ICU patients. However, current point of care (POC) glucometers used in the ICU have been found to be inaccurate in the presence of low hematocrit (HCT) values. The purpose of this study was to analyze error rates of four current POC glucometers and determine the correction factor required based on a patient's HCT value.

**Methods:** 205 blood samples taken from a random cohort of ICU patients were tested on four frequently used POC glucometers (G1-G4) and compared with laboratory values. Samples were collected in all ICUs in the facility, and include trauma, surgical, medical, cardio-thoracic, and burn patients. Error rates between each glucometer and laboratory values were analyzed based on the patient's HCT. A mathematical correction factor was derived from the glucometer reading, the patient's HCT, and glucometer type.

**Results:** Significant glucometer error rates were found for HCT values < 34%. POC glucometers had consistently falsely elevated values compared to the standard laboratory tests. Glucometer error rates for HCT < 25% ranged from 15.1% to 23.4% for the four types. Error rates for 25% < HCT < 34% ranged from 15.2% to 18.39% for the four types. A correction formula for each glucometer based on the natural log transform of the HCT reduced the mean error rate for each glucometer to -0.02%±4.78 for G1, 0.18%±6.29 for G2, 0.20%±6.22 for G3, and 0.22%±7.9 for G4 compared to the laboratory values.

**Conclusions:** Use of POC glucometers in the ICU will result in falsely elevated glucose measurements in the presence of HCT values < 34%. Utilizing POC devices designed for the outpatient setting in the ICU with intensive insulin therapy and restrictive transfusion practices is suboptimal. Correction of this error is possible with a simple mathematical formula that allows for a rapid calculation of the true serum glucose value. Clinical use of the correction formula has been implemented in our ICUs.

**TEMPORARY VASCULAR SHUNTS AS INITIAL TREATMENT OF PROXIMAL EXTREMITY VASCULAR INJURIES DURING COMBAT OPERATIONS: THE NEW STANDARD OF CARE AT LEVEL II FACILITIES?**

Richard Sharpe MD, Janos Taller MD, Jinu Kamdar MD, Robert Morgan MD, Jeff Greene PA, Charles Blakenship MD, Paul Dabrowski MD(\*), Naval Medical Center, San Diego, CA

**Invited Discussant:** David V. Feliciano, M.D.

**Introduction:** Historically, penetrating injuries to the extremities account for up to 75% of wounds sustained during combat and 10% of deaths. Rapid vascular control and perfusion of injured extremities at forward deployed Level II surgical facilities is essential to limit loss of life and maximize limb preservation. We review our experience with the management of extremity vascular trauma and report the largest single center experience to date on temporary vascular shunting (TVS) for proximal extremity vascular injuries.

**Methods:** Data on combat trauma patients presenting to a US Navy Level II forward surgical facility in Iraq were prospectively recorded during a 7 month period. Patients with suspected vascular injuries underwent exploration in the operating room. After vessel control, thrombectomy and instillation of heparinized saline, vascular injuries in the proximal extremity were temporarily shunted with Argyle or Javid shunts in a unique, standardized fashion. Vascular injuries in the distal extremity were routinely ligated. Patients underwent vascular reconstruction at a Level III facility and were followed through discharge or transfer to Continental US. Shunt patency, limb salvage and survival data were obtained by retrospective review of electronic medical records.

**Results:** 610 combat trauma patients were treated from Aug 2006 to Feb 2007. 37 patients (6.1%) sustained 73 injuries to major extremity vascular structures. 23 proximal vascular shunts were placed in 16 patients with a mean ISS of 25 (range 17 – 43) and a mean MESS of 8 (range 5 – 10). 22 of 23 shunts (95.6%) were patent at the Level III facility and underwent successful autologous vein reconstruction. These patients all survived with 100% early limb preservation. Additionally, 15 patients with ligation of distal vascular injuries also had successful limb salvage.

**Conclusion:** Complex combat injuries to proximal extremity vessels should be routinely shunted at forward-deployed Level II facilities as part of the resuscitative, damage control process.



**THE NECESSITY TO ASSESS ANTICOAGULATION STATUS IN ELDERLY TRAUMA PATIENTS**

Trevor Williams, MD, MPH, Alden Harken, MD, Gregory Victorino\*, MD, UCSF-East Bay, Oakland, CA

**Invited Discussant:** Donald R. Kauder, M.D.

**Objectives:** The literature on outcomes for anticoagulated trauma patients is unclear. The objectives of this study were to explore an elevated INR (international normalized ratio) as an enhancer of morbidity and mortality in injury and age stratified elderly trauma patients and to consider the cost-effectiveness of INR testing.

**Methods:** We retrospectively examined 5 years of trauma registry data which included 2094 patients aged 50 or greater. Admission INR was defined as an INR drawn within the first 2 hours of admission, provided there was not a greater than 2 gm/dl drop in hemoglobin during the first 5 hours from admission. Admission INR was analyzed as a dichotomous and a continuous variable to determine the effect of smaller changes in INR level on mortality.

**Results:** Forty-nine of the 690 patients with admission INR determinations had an admission INR > 1.5. The median injury severity scores were 9 for the INR > 1.5 group and 8 for the INR < 1.5 group. Despite similar injury severity, the mortality was almost three fold higher for the INR > 1.5 group (26.5% vs. 9%,  $p < 0.01$ ). After adjusting for age and injury severity score, the odds of death was 2.5 for the INR > 1.5 group compared to the INR < 1.5 group (95% CI 1.1-5.8;  $p = 0.03$ ). Using INR as a continuous variable, and after controlling for age, ISS and INR, the multivariate model gave a mortality risk estimate of 37% for a one unit increase in INR (OR 1.37, 95% CI 1.03-1.82;  $p = 0.03$ ). Hospital cost was estimated at \$5 per INR blood draw.

**Discussion:** We conclude that an elevated admission INR level is independently associated with increased mortality in trauma patients aged 50 and older after adjusting for age and ISS. Considering the low cost of an INR and the potential reduction in costs associated with traumatic brain injury, these data support the recommendation to assess a coagulation profile in elderly trauma patients in order to identify earlier those in need of closer monitoring and a more aggressive reversal of their anticoagulation.

**FLUID RESUSCITATION WITH 5% ALBUMIN RESULTS IN LESS SEVERE DILUTIONAL COAGULOPATHY, LOWER BLOOD LOSS AND GREATER SURVIVAL THAN SYNTHETIC COLLOIDS**

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**Invited Discussant:** Charles E. Lucas, M.D.

**Introduction:** Based on logistic benefits of colloids over crystalloids, the U.S. military selected Hextend for resuscitation of combat casualties in the field. We investigated the effects of resuscitation with this fluid, as well as other colloids, on coagulation and uncontrolled bleeding of rabbits with splenic injury.

**Methods:** Anesthetized male NZW rabbits ( $3.3 \pm 0.2$  kg) were divided into 3 groups and subjected to hypothermia ( $34.5 \pm 0.5^\circ\text{C}$ ) and 40% isovolemic blood exchange (hemodilution) with Hextend (H); Dextran70 (D); or 5% human albumin (A) solution ( $n=8/\text{group}$ ). CBC, ABG, and coagulation values were measured before and after hemodilution. Laparotomy was performed and a standard splenic injury causing uncontrolled hemorrhage was made. Rabbits were resuscitated (25 ml/kg) with the same colloid used for hemodilution to restore baseline mean arterial pressure (MAP). Animals were monitored for 2 hrs or until death. Blood loss and survival time were measured. Data were analyzed by Kruskal-Wallis and Logrank tests and expressed as mean  $\pm$  SEM.

**Results:** There were no differences among groups in MAP, pH, Hct, fibrinogen or platelets before or after hemodilution. Hct, fibrinogen and platelets were reduced by ~50% in all groups. Hemodilution with H and D resulted in more severe coagulopathy than with A (table). Subsequent splenic hemorrhage led to death of 100% (H), 75% (D) and 50% (A) of coagulopathic rabbits. [ $^+ P < 0.01$  vs. D or H;  $^* P < 0.01$  vs. H.]

g	PT(s)	aPTT(s)	TEG R (min)	TEG K(min)	TEG MA	TEG Vmax	Bld loss (ml/kg)	Survive (min)
H	$13.3 \pm 0.3$	$44.4 \pm 3.0$	$4.6 \pm 0.2$	$4.4 \pm 0.5$	$36.3 \pm 1.4$	$5.7 \pm 0.4$	$53.9 \pm 1.5$	$66 \pm 5$
D	$13.6 \pm 0.2$	$44.6 \pm 4.6$	$4.9 \pm 0.2$	$3.5 \pm 0.2$	$39.9 \pm 0.9$	$6.5 \pm 0.4$	$54.4 \pm 1.2$	$96 \pm 9$
A	$15.0 \pm 0.4^+$	$52.8 \pm 6.3$	$3.8 \pm 0.3^*$	$1.9 \pm 0.1^+$	$49.0 \pm 1.7^+$	$11.4 \pm 0.6^+$	$37.3 \pm 4.1^+$	$107 \pm 7^*$

**Conclusion:** Plasma PT and aPTT results underestimated the degree of coagulopathy produced by H and D compared to TEG analysis of whole blood. These results suggest that resuscitation with albumin maintained coagulation function, decreased blood loss and improved survival time better than the synthetic colloids.

**UNI-SERVICE MANAGEMENT OF TRAUMA PATIENTS IMPROVES  
EFFICIENCY OF CARE AND AUGMENTS FINANCIAL REMUNERATION**

KA Davis MD\*, T Leary MBA, C Carusone RN, FY Lui MD, KM Schuster MD and LJ Kaplan MD\*, Yale University, New Haven, CT

**Invited Discussant:** C. William Schwab, M.D.

**Introduction:** The purpose of this study was to determine whether a paradigm shift in management at our institution, from a multi-service to a uni-service model would improve the efficiency with which care was delivered, and would increased both physician and hospital reimbursement for care.

**Methods:** All patients activating the trauma team at a Level I trauma center over 2 time periods (last 6 months of 2005 and 2006) were reviewed. Trauma team activation criteria remained constant across the two time periods. During 2005, patients were admitted to multiple services, while in 2006, most patients were admitted to the trauma service. In 2006, improved documentation and appropriate coding was encouraged. Data is reported as mean  $\pm$  SD, and median.

**Results:** Patient demographics and payor mix were similar over the two time periods. The number of full-time trauma surgeons increased from four to five.

	2005	2006	p value
Trauma activations	407	651	
Admitted to trauma service	68%	86%	<0.0001
ISS	15 $\pm$ 15 (9)	12 $\pm$ 11 (9)	<0.0001
Hospital LOS (days)	12 $\pm$ 58 (3)	6 $\pm$ 11 (2)	0.023
Trauma surgeon RVUs	2738	5000	0.0001
Trauma surgeon charges	\$209,202	\$913,661	0.002
Trauma surgeon collections	\$65,673	\$195,619	0.013
Hospital charges per patient	\$64,000 $\pm$ 130,000	\$47,000 $\pm$ 72,000	0.007
Hospital revenue per patient	\$22,000 $\pm$ 44,000	\$18,000 $\pm$ 37,000	NS
Actual hospital cost per patient	\$26,000 $\pm$ 56,000	\$17,000 $\pm$ 29,000	0.0006
Net hospital margin per patient	\$ - 4,000 $\pm$ 42,000	\$ 1,000 $\pm$ 24,500	0.014

**Conclusions:** Implementation of uni-system management resulted in increased efficiency of care delivery, with shorter hospital lengths of stay despite higher patient volume. This paradigm change, coupled with improved documentation and coding, resulted in improved reimbursement not only for the physician, but also for the hospital.

**SAFETY AND EFFICACY OF PRE-HOSPITAL NARCOTICS IN AIR-TRANSPORTED TRAUMA PATIENTS: RESULTS OF A PROSPECTIVE STUDY**

James G Hinsdale MD\*, Scott Weyland RN, California Shock/Trauma Air Rescue, San Jose, CA

**Invited Discussant:** Jeffrey P. Salomone, M.D.

**Goal:** To assess prospectively whether pre-hospital narcotics can be given safely in trauma patients with undiagnosed pain and to evaluate their effectiveness in pain control.

**Methods:** The study period was 3<sup>rd</sup> quarter, 2006. All patients transported by air ambulance were deemed candidates for pain relief and the protocol specified titrating pain relief to a level of 5, using the 1 – 10 pain scale. Patients were excluded if there were physiologic instability (systolic blood pressure (BP) < 100) or pain level < 6. Data points measured were BP, pulse (P), respirations (R), temperature (T), Glasgow Coma Scale (GCS), pain level pre- and post narcotic administration, scene time, flight time, disposition at receiving facility, age, sex, mechanism, anatomical injury area, and survival. Data are mean +/- standard error of mean. Significance was measured by paired t – test.

**Results:** 173 consecutive patients were reviewed during the 3<sup>rd</sup> quarter, 2006. 100 patients received narcotics (N), 98 of these as fentanyl, 2 as morphine. 73 patients did not receive narcotic (NN). The pre-dosing pain level in the N group was 8.6 +/- .43. This lowered to 4.2 +/- .32 (p < .005) after medication. The mean fentanyl dose was 104 ug +/- 24. The mean pain level in the NN group was 2.49 +/- .05. There were no differences between N and NN in age, sex, flight or scene time. BP, P, R, T and GCS were unchanged after narcotic in the N group. There was one death, a suicide victim in the NN group. Ten patients received intubation, all in the N group (p < .05). The NN group had a higher discharge rate (48%) from the ER than the N group (12%, p < .05). One patient in the N group received reversal with Narcan, in retrospect due to a language barrier.

**Conclusion:** Pain relief by short-acting agents (fentanyl) can be given safely by trained flight personnel in pre-hospital transport. Significant reductions in pain level are achievable, down to levels that allow receiving clinicians to evaluate the patient and maintain diagnostic focus. There is little justification for withholding pain relief during transport to trauma patients who are physiologically stable.

**USE OF 23.4% HYPERTONIC SALINE FOR THE MANAGEMENT OF ELEVATED INTRACRANIAL PRESSURE FOLLOWING SEVERE TRAUMATIC BRAIN INJURY: A PILOT STUDY**

Andrew J. Kerwin MD\*, Miren A. Schinco MD\*, Joseph J. Tepas, III MD\*, Elizabeth A. Vitarbo MD, Garrett Chumney MD, Michael Muehlberger MD, Bill Renfro PharmD, University of Florida HSC, Jacksonville, FL

**Invited Discussant:** Raul Coimbra, M.D., Ph.D.

**Introduction:** Oncotic agents are a therapeutic mainstay for intracranial hypertension. Both mannitol and different concentrations of hypertonic saline (HTS) have been shown to be effective at reducing intracranial pressure (ICP). We compared the safety and efficacy of 23.4% HTS to mannitol for acute management of elevated ICP.

**Methods:** After approval from our IRB, the records of patients admitted with severe TBI who received mannitol or HTS were reviewed. Demographic and physiologic data were recorded. ICP, cerebral perfusion pressure (CPP), ICP reduction following dose administration, serum sodium, osmolality, and duration of dose response were analyzed. Efficacy was determined by comparison of proportion of patients with any response, and mean change in ICP, using Chi-square, accepting  $p < .05$  as significant. Safety was determined by recording any new post infusion electrolyte or neurologic anomalies.

**Results:** Twenty-two patients with severe TBI required 210 doses of either mannitol or HTS. All patients suffered severe blunt injury (mean ISS  $28 \pm 11$ ). HTS patients had a significantly higher ICP at the initiation of therapy (30.7 vs. 28.3, respectively). There was no difference in initial CPP. Mean ICP reduction in the hour following administration of 102 doses of mannitol and 108 doses of HTS was greater for patients receiving HTS (9.3 vs. 6.4, HTS vs. mannitol,  $p = .0028$ ,  $\chi^2$ ). More patients responded to HTS (92.6% HTS vs. 74% mannitol,  $p = .0002$ ,  $\chi^2$ ) There was no significant difference between groups in the duration of ICP reduction following dose administration (4.1 vs. 3.8 hours; HTS vs. mannitol). No adverse events following administration of either agent were identified.

**Conclusions:** 23.4% HTS is safe, and more efficacious than mannitol in reducing ICP. Considering these findings, it should be considered the treatment of choice for ICP reduction when electrolyte concentration and osmolality are appropriate.

**RECOMBINANT FACTOR VIIA: DECREASING TIME TO INTERVENTION IN COAGULOPATHIC PATIENTS WITH SEVERE TRAUMATIC BRAIN INJURY**

Deborah M. Stein MD MPH, Richard P. Dutton MD MBA, Mary E. Kramer RN, Thomas M. Scalea MD\*, R Adams Cowley Shock Trauma Center, University of Maryland School of Medicine, Baltimore, MD

**Invited Discussant:** Peter B. Letarte, M.D.

**Objective:** Treatment of coagulopathy is often needed prior to neurosurgical intervention in patients with traumatic brain injury (TBI). Typically, this is accomplished with fresh frozen plasma (FFP). We hypothesized that the off-label use of recombinant factor VIIa (rFVIIa) to normalize the coagulation profile would allow for earlier intervention than conventional therapy.

**Methods:** The trauma registry identified patients with severe TBI (Head AIS>3, admission GCS<9) admitted over a 4-year period who were coagulopathic on admission (INR>1.3) and required a neurosurgical procedure. Demographics, injury, blood bank and laboratory data, time of procedure, rFVIIa use, and complications were abstracted. Characteristics of the group who received rFVIIa were compared against those treated with FFP alone with a Student’s t-test.

**Results:** Of 681 patients with severe TBI, 63 were coagulopathic on admission and needed an emergent neurosurgical procedure. 29 patients who received rVIIa were compared against 34 patients who were treated with only FFP. Mean age, ISS, and admission GCS and INR were not different between the two groups. Time to intervention was less in the rFVIIa group (median = 144’ vs.

280’) as were the number of units of FFP administered prior to procedures (median = 2 vs. 6).

Thromboembolic complications were no different between groups.

In patients with isolated TBI, mortality was 33.3% in the rFVIIa group and 52.9% in controls (p=0.25).

	rVIIa (n=29)		No rVIIa (n=34)		p value
	mean	±	mean	±	
Age (years)	40.1	25.7	38.1	21.9	0.752
ISS	37.7	14.8	38.9	13.2	0.585
Adm. GCS	4.6	1.8	4.4	1.7	0.489
Adm. INR	2.1	1.1	1.9	1.0	0.412
<b>Time to Procedure (minutes)</b>	<b>275</b>	<b>283</b>	<b>500</b>	<b>327</b>	<b>0.006</b>
<b>FFP prior to Procedure (units)</b>	<b>4.4</b>	<b>6.6</b>	<b>8.5</b>	<b>7.0</b>	<b>0.021</b>
	<b>n</b>	<b>%</b>	<b>n</b>	<b>%</b>	
Mortality	10	34.5	11	32.3	0.853
Complications	5	17.2	6	17.9	0.992

**Conclusion:** rFVIIa rapidly and effectively reversed coagulopathy in patients with severe TBI. rFVIIa decreased the time to intervention and decreased the use of blood products without increasing the rate of thromboembolic complications.

## MALE GENDER IS ASSOCIATED WITH EXCESSIVE IL-6 EXPRESSION FOLLOWING INJURY

Jason L. Sperry MD MPH, Randy S. Friese MD\*, Heidi L. Frankel MD\*, Michael A. West MD PhD\*, Joseph Cuschieri MD\*, Ernest E. Moore MD\*, Brian G. Harbrecht MD\*, Ronald V. Maier MD\*, Joseph P. Minei, MD\* University of Texas Southwestern, Dallas, TX

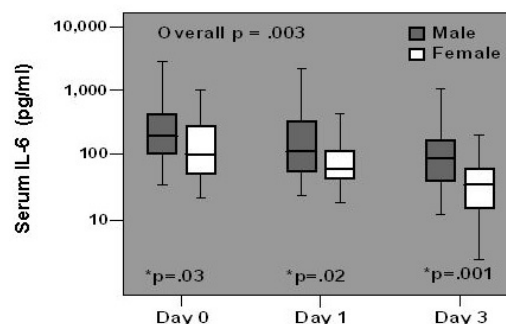
**Invited Discussant:** Gail T. Tominaga, M.D.

**Objective:** We have previously shown that male gender is independently associated with a 40% higher rate of multiple organ failure (MOF) following injury (unpublished), but a mechanism for this dimorphic response has not been fully characterized.

**Methods:** Data were obtained from a multi-center prospective cohort study evaluating clinical outcomes in severely injured adults with blunt hemorrhagic shock. Proteomic analysis of serum inflammatory cytokines, on days 0, 1 and 3 post injury, was performed on 46 males and 34 females. Variables were log transformed for normality assumptions. Repeated measures ANOVA (general linear model) was used to compare serial IL-1 $\beta$ , TNF- $\alpha$ , and IL-6 serum levels across gender, while controlling for important confounders.

**Results:** Overall mortality and MOF (MODS > 5) rates were 5% and 34% respectively. Males and females were statistically similar in age, initial base deficit, ISS, resuscitation requirements (blood, crystalloid, and vasopressor use), GCS and comorbidities. There were no differences across gender for IL-1 $\beta$  (p=0.62) and TNF- $\alpha$  (p=0.22) levels. However, IL-6 levels were significantly elevated in males compared to females overall, independent of age, ISS, base deficit and blood transfusion requirements (p=0.003), and at each time point, after correcting for multiple comparisons (Figure, Holm-Bonferroni correction \*). Males also had a significantly higher incidence of multiple organ failure (52% vs. 9%, p<.001).

**Conclusion:** Persistently elevated IL-6 levels in males are associated with a higher rate of MOF. It is not known if this excessive IL-6 expression in males is causal or only a marker for poor outcome. Further studies are required to elucidate if this early, persistent IL-6 expression is responsible for the gender based differential outcomes following injury.



**STRESS INSULIN RESISTANCE IS A MARKER FOR MORTALITY IN TRAUMATIC BRAIN INJURY**

Nathan T. Mowery, MD; Oliver L. Gunter, Jr., MD; Oscar D. Guillamondegui, MD; Marcus Dortch, PharmD; John A. Morris, Jr. MD\*; Addison K. May, MD\*; Vanderbilt University, Nashville, TN

**Invited Discussant:** R. Todd Maxson, M.D.

**Introduction:** Both hyper- and hypoglycemia have been associated with poor outcome in traumatic brain injury (TBI). Neither the risks nor benefit of tight glucose control (goal range 80-110 mg/dL) has been documented in the TBI population.

**Objective:** To determine if densely collected computerized tight glycemic control will reveal significant differences in blood glucose between survivors and non-survivors in patients with TBI.

**Methods:** From October 2005 – April 2006 all ventilated, critically ill surgical patients with traumatic brain injury AIS ? 3 were placed on an automated, euglycemia protocol with q 2 hour blood glucose sampling. Mortalities within 24 hours were excluded. The protocol calculates the insulin rate using a linear equation (rate = blood glucose – 60[M]). M is an adapting multiplier and used here as a marker for insulin resistance.

**Results:** Of 1636 trauma ICU admissions 160 patients, (mean ISS 37, mortality 13.1%) had 10,071 samples collected. Median glucose 115.6, with 41% of values between 80-110, 81% between 80-150, and 0.3% < 40 Logistic regression models demonstrated insulin rate (OR 0.736, 95% CI, 0.549-0.985,

p=0.039) or the multiplier (p=0.019) to be the most closely associated with mortality.

**Conclusion:** Non survivors with TBI have significantly higher markers of insulin resistance

Continuous values expressed as median	Lived (n=139)	Died (n=21)	p
ISS	34.0	38.0	0.149
<b>Blood Glucose</b>	<b>114.0</b>	<b>118.3</b>	<b>0.011</b>
<b>Admission Glucose</b>	<b>153</b>	<b>207</b>	<b>0.002</b>
<b>Insulin Rate</b>	<b>3.2</b>	<b>4.2</b>	<b>0.006</b>
<b>Multiplier (M)</b>	<b>0.057</b>	<b>0.070</b>	<b>0.033</b>
% of values in range (80-110 mg/dL)	41.6%	39.2%	0.129
Glucose ? 60 mg/dL	2.1%	2.1%	0.916

(insulin rate and multiplier). Markers of glucose control (median glucose, hypoglycemic episodes and the percentage of values in range) did not differ clinically among groups.

Despite this stress insulin resistance tight glycemic control appears possible and safe with low levels of hypoglycemic episodes in the traumatic brain injury population.



## IMPROVED SURVIVAL OF CRITICALLY ILL TRAUMA PATIENTS TREATED WITH RECOMBINANT HUMAN ERYTHROPOIETIN

LM Napolitano MD\* University of Michigan Health System, T Fabian MD\* University of Tennessee Health Science Center, JA Bailey MD\* St. Louis University School of Medicine, EF Block MD\* Orlando Regional Medical Center, AK May MD\* Vanderbilt University Medical Center, HL Corwin MD Dartmouth-Hitchcock Medical Center

**Invited Discussant:** Leopoldo Cancio, M.D.

**Objective:** A randomized, double-blind placebo-controlled multicenter trial (EPO2, N=1302) in critically ill pts demonstrated a 29-day survival benefit in the trauma subgroup receiving rHuEPO (mortality 8.9% vs. 4.1%, RR 0.47, CI 0.25 - 0.89). A second trial (EPO3, N=1460) confirmed this survival benefit in the rHuEPO-treated trauma cohort (mortality 6.7% vs. 3.5%, RR 0.52, CI 0.28 - 0.99). This analysis presents trauma cohort data from both trials for critical evaluation of specific trauma variables affecting outcome.

**Methods:** Pts received 40,000 U rHuEPO or placebo weekly, for a total of 4 (EPO2) or 3 (EPO3) doses, starting on ICU day 3. EPO3 mortality was adjusted by logistic regression for baseline demographics: hemoglobin; iron; APACHE II; race; and trauma variables.

Mean (SD)	EPO 2 Trauma		EPO 3 Trauma	
	Placebo n = 316	rHuEPO n = 314	Placebo n = 391	rHuEPO n = 402
Age (years)	41.8 (18.5)	41.6 (18.5)	40.2 (17.0)	41.1 (17.5)
APACHE II Score (Adm)	18.1 (7.3)	18.5 (7.8)	18.7 (6.6)	19.2 (7.4)
Injury Severity Score, ISS	25.6(11.4)*	25.7(12.3)*	28.0 (12.5)	28.1 (12.4)
Rev. Trauma Score, RTS	6.5(1.7)*	6.6(1.7)*	6.1 (2.0)	6.3 (1.8)
Glasgow Coma Score, GCS	11.3(4.6)*	11.4(4.6)*	10.1 (5.1)	10.6 (5.0)
Adm Shock Index (HR/SBP)	0.9(0.4)*	0.9(0.4)*	0.8 (0.2)	0.7 (0.2)
Baseline hemoglobin	9.8 (1.2)	9.8 (1.2)	9.3 (1.2)	9.4 (1.2)
Mortality, Day 29 (n, %)	28 (8.9%)	13 (4.1%)	26 (6.7%)	14 (3.5%)

**Results:** Demographic and trauma variables were comparable. Adjusted mortality confirmed the non-adjusted Day 29 mortality benefit for rHuEPO-treated trauma pts (EPO3 - OR 0.37, 95% CI 0.18 – 0.74.) Mortality was consistently reduced by ~50% in both studies. In EPO3, there was an increase in thrombovascular events in the rHuEPO treated group (16.4% vs 12.6%, RR 1.3, 95% CI 0.93,1.84) but not in EPO2 (13% vs 16%, RR 0.82 , 95% CI 0.55,1.18).

**Conclusion:** rHuEPO demonstrated a survival advantage in both of the critically ill trauma pt cohorts, with no differences in trauma-specific outcome variables identified.

\* Data for these variables collected retrospectively.

**MISSED SICU BILLING: POTENTIAL FINANCIAL IMPACT OF 24/7  
FACULTY PRESENCE**

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**Invited Discussant:** R. Lawrence Reed, II, M.D.

**Introduction:** In an attempt to efficiently capture evaluation and management (E&M) and procedural billing in our surgical intensive care unit (SICU), we have developed an electronic billing system which links to the electronic medical record (EMR). In this system, notes must be electronically signed and coded by an attending to generate charges. We hypothesized that missed billing during night-time or weekends might financially justify 24/7 in-house attending coverage.

**Methods:** Retrospective EMR review of SICU admissions during a recent 2 month period. Note type, date, time, and presence/absence of faculty signatures and coding were analyzed.

**Results:** 443 patients had 465 admissions and 2,896 notes, 76% of which were signed and coded by an attending. Unsigned/uncoded notes represented an estimated missed billing opportunity of \$149,346 for 2 months. Missed billing was ~\$320 per admission. Unbilled evaluation and management (E&M) and procedures from night-time and weekends totaled \$80,776 (\$40,246 and \$40,530 respectively). This represents ~\$485K annually, extrapolating to ~\$205K in collections from our payor mix. Interestingly, missed E&M and procedural billing during weekdays totaled an estimated \$54,758 (\$328,548 annually). In review, these typically represented patients seen, but transferred from the SICU before attending documentation was completed.

**Conclusions:** Identifying specific deficiencies in documentation can help create solutions for missed billing opportunities in the SICU. We have identified approximately \$900K annually of missed billing in our SICU population. Missed E&M and procedural billing during weeknights and weekends represented more than half of this, and 24/7 in-house faculty coverage should generate enough revenue to be financially feasible. We are also endeavoring to recover missed revenues during daytime hours by development of a concurrent missed documentation report.

**PREEMPTIVE ANTIBIOTICS TREATMENT USING GRAM STAIN REDUCED THE INCIDENCE OF ARDS IN MECHANICALLY VENTILATED PATIENTS**

Asako Matsushima, MD, Osamu Tasaki, MD, Kentaro Shimizu, MD, Kazunori Tomono, MD, Hiroshi Tanaka, MD\*, Takeshi Shimazu, MD\*, Hisashi Sugimoto, MD\*, Osaka University, Osaka, Japan

**Invited Discussant:** Therese M. Duane, M.D.

**Introduction:** Ventilator-associated pneumonia (VAP) is one of the major complications of intensive care unit (ICU), which sometimes results in acute lung injury (ALI) and ARDS that associated with high mortality.

**Hypothesis:** In the present study, we hypothesized that preemptive therapy of respiratory infection using bedside gram stain guided us to use appropriate antibiotics, and reduced the incidence of VAP.

**Methods:** The patients who stayed in our medical-surgical ICU with endotracheal intubation for more than 72 hours were included in this study. The patients who were under the age of 16 or died due to brain death were excluded from this study. The study was divided into two periods. In the first period, we used antibiotics according to the guideline for VAP. In the second period, we performed gram stain of purulent tracheobronchial secretions of patients with high fever or leukocytosis, and started antibiotics depend on the gram stain findings even before the lung infiltration on chest X-ray appeared.

**Results:** One hundred-twenty eight patients and 133 patients were included in the first and second period respectively. The age, APACHE ?score and ISS score were not significantly different between the two periods. The incidence of VAP decreased significantly in the second period (1<sup>st</sup> period 22 %, 2<sup>nd</sup> period 9 %,  $p < 0.01$ ). The incidence of ARDS ( $\text{PaO}_2 / \text{F}_i\text{O}_2 \leq 200$ ) also decreased significantly in the second period (1<sup>st</sup> period 11 %, 2<sup>nd</sup> period 3 %,  $p < 0.01$ ). The duration of antibiotics treatment was shorter in the second period, which resulted in the reduction of the total antibiotics administration. The mortality associated with VAP was significantly lower in the second period in comparison with the first period (1<sup>st</sup> period 5 %, 2<sup>nd</sup> period 0.8 %,  $p < 0.05$ ).

**Conclusions:** The early diagnosis and treatment of respiratory infection based on gram stain significantly reduced the incidence of VAP and ARDS without increasing the use of antibiotics.

**THE NEED FOR IMMEDIATE CT SCAN FOLLOWING EMERGENCY  
CRANIOTOMY FOR HEAD INJURY**

Michael J. Sise MD, Thomas W. Carver MD, Gabrielle M. Paci BA, Daniel I. Sack BA, Amy Hunstock, Lance L. Altenau MD, Scripps Mercy Hospital, San Diego, CA

**Invited Discussant:** James E. Wilberger, M.D.

**Background:** Patients who undergo emergency craniotomy for head injury require vigilant postoperative care to obtain the best possible outcome. Although repeat CT scans are a key component of the management of these patients, there is no consensus on the optimal timing of the initial postoperative CT scan (PCT).

**Methods:** We conducted a retrospective registry-based review of the care of 198 consecutive trauma patients who underwent craniotomy for head injury at a Level I trauma center to evaluate the role of PCT in their management.

**Results:** One hundred and ninety-eight patients underwent 222 craniotomies for head injury during the 78 month study period. Mean age was 48 years and 74% were male. The primary indication for operation included subdural hematoma (SDH) in 124 (55.9%), epidural hematoma (EDH) in 47 (21.2%), decompressive craniectomy (DC) in 24 (10.8%), and other indications in 27 (12.2%). Overall survival was 72%. PCTs were obtained after 199 (89.6%) of the operations at a mean of 22.2 hours. There were a variety of unexpected findings with clinical implications on these scans and 14 (7.1%) patients required a second craniotomy in the two days following their initial operation. The indications for these operations were SDH in four (28.6%), EDH in five (35.7%), DC in four (28.6%), and other in one (7.1%). In six (3.0%) patients, an earlier PCT might have prevented a significant delay in operation. PCTs were obtained between 4.4 and 22.9 hours after initial craniotomy in these six patients. Findings in these patients included recurrent EDH or SDH in two patients, contralateral EDH in one patient, and intracerebral hemorrhage in three patients. Neither neurologic examination nor postoperative intracranial pressure monitoring reliably predicted the presence of new or recurrent hemorrhage or other significant findings.

**Conclusion:** Early, if not immediate, PCT following emergency craniotomy for head trauma appears to be warranted. We found a significant incidence of unexpected findings on PCT and encountered avoidable delays in treatment of new or recurrent findings.

## DOSE-RESPONSE RELATIONSHIP BETWEEN NOREPINEPHRINE AND ERYTHROPOIESIS: EVIDENCE FOR A CRITICAL THRESHOLD

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**Invited Discussant:** Richard S. Miller, M.D.

**Background:** Severe traumatic injury elicits a neuroendocrine response that activates the sympathetic nervous system. Our previous work suggests that norepinephrine (NE) influences the bone marrow (BM) erythropoietic response. However, the dose-response relationship between NE and erythropoiesis remains unclear.

**Methods:** Two days following chemical sympathectomy with 6-hydroxydopamine (6-OHDA) or injection with saline vehicle (SHAM), male Sprague-Dawley rats were infused continuously with either saline (NS) or varying doses of NE for 5 days via intraperitoneal osmotic pumps. Erythropoiesis was assessed by growth of erythroid progenitor colonies (BFU-E and CFU-E). Data are presented as mean±SD; \*p<.05 by ANOVA and Tukey-Kramer.

**Results:** SHAM rats with continuous infusion of NE show a clear dose-response effect for both BFU-E and CFU-E (Fig.1A). In the 6-OHDA rats, continuous infusion of NE partially restored BFU-E and CFU-E growth at  $10^{-8}$ g/hr and  $10^{-9}$ g/hr, respectively (Fig.1B).

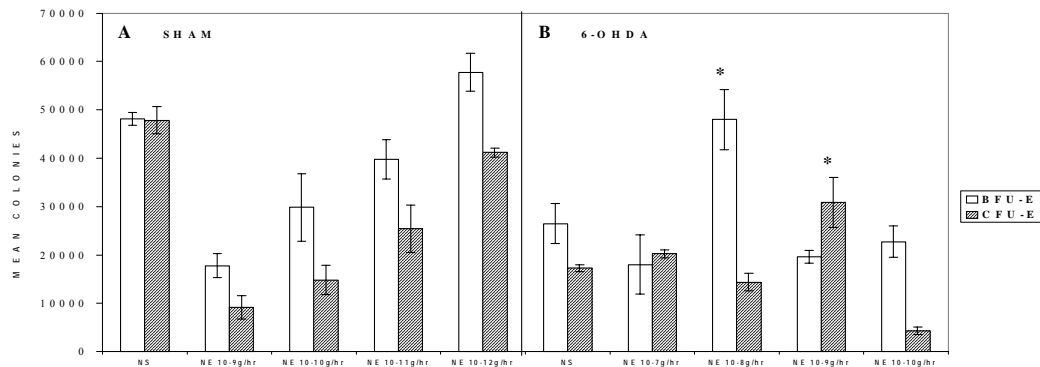


Figure 1A. Continuous NE infusion has a dose-dependent effect on BFU-E and CFU-E in SHAM rats.  
Figure 1B. NE infusion rescues BFU-E and CFU-E growth at  $10^{-8}$ g/hr and  $10^{-9}$ g/hr in 6-OHDA rats. \*p<.05 (N=3-6/group)

**Conclusions:** Erythropoiesis is maintained by physiologic levels of NE. Supraphysiologic doses inhibit erythropoiesis in a dose-dependent manner. Chemical sympathectomy results in a reduction of erythropoiesis that is partially restored by NE, but only in a narrow window. These data suggest that NE has a complex interaction with the BM and elevation of NE following traumatic injury affects BM erythropoietic function.

**MEAN GLUCOSE VALUES PREDICT TRAUMA PATIENT MORTALITY**

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**Invited Discussant:** Michael J. Allshouse, D.O.

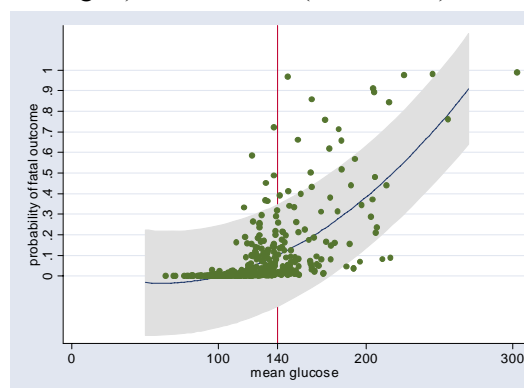
**Introduction:** One randomized, prospective study of tight glycemic control in a mixed SICU patient population demonstrated improved survival, and others have shown decreased infection rates.

**Hypothesis:** We postulated glucose levels <150 mg/dl would improve infectious complications and mortality in trauma patients admitted to our ICU.

**Methods:** Adult trauma patients in our ACS level I Trauma Center ICU from 7/2004 through 6/30/2006 were studied. Insulin therapy was instituted for ICU patients admitted after 7/1/2005 with glucose >150 mg/dl. Infections and all glucose values were collected. Multivariate analysis adjusting for age, ISS, GCS, admit blood pressure and intubation status was performed.

**Results:** 531 ICU patients were admitted with a mean ISS of  $23 \pm 13$  and mean age of  $45 \pm 19$  years. The admission, mean and maximum glucoses were 141, 129, and 192 respectively. In multivariate analyses, while increases in all three glucose values were significantly associated with higher mortality, the best model was achieved for mean glucose with a ROC of 0.90 (Figure). For mean glucose categories of >200, 140-200, and <140 mg/dl, the mortality was 40%, 20%, and 3.3%, respectively. Higher glucose levels were associated with increased infection (mean glucose of 133 for those with infection and 127 mg/dl for those without infection); however, in multivariate analysis, mean glucose did not remain an independent predictor of infection. The use of insulin drips rose from 13 to 22% ( $p=0.01$ ), the number of glucose checks increased from 27 to 43 ( $p<0.02$ ) yet there was no associated decrease in mean (129 versus 129 mg/dl) or maximum (189 vs 194) glucose levels.

**Conclusion:** Higher glucose levels were significantly associated with risk of fatal outcome in trauma patients, even after adjusting for age, ISS, GCS, intubation status and admission blood pressure. Unlike previous studies, hyperglycemia was not an independent predictor of infectious complications.



**DAMAGE CONTROL HEMATOLOGY: THE IMPACT OF A TRAUMA  
EXSANGUINATION PROTOCOL ON SURVIVAL AND BLOOD PRODUCT  
UTILIZATION**

Bryan A Cotton, MD, Oliver L Gunter, MD, James Isbell, MD, Brigham K Au, BS, John A Morris, Jr, MD,\* Amy M Robertson, MD, Paul St.Jacques, MD, Pampee P Young, MD, Vanderbilt University Medical Center, Nashville, TN

**Invited Discussant:** Larry J. Butler, M.D.

**Introduction:** The importance of early and aggressive management of trauma-related coagulopathy has, until recently, been under-studied and overlooked. In addition, transfusion strategies necessary to rapidly address these parameters remain poorly defined. We hypothesized that a trauma exsanguination protocol (TEP) would improve survival and reduce overall blood product consumption among the most severely injured patients.

**Methods:** We recently implemented a TEP, which involves the immediate and continued release of predefined ratios of RBC, FFP, and platelets. All TEP activations from 02/01/06-01/31/07 were evaluated. A comparison cohort (pre-TEP) was chosen from all trauma patients admitted between 02/01/05-01/31/06 that (1) underwent immediate surgery by the trauma team and (2) received greater than 10 units of RBC in the first 24 hours.

**Results:** 139 patients met inclusion criteria; 69 TEP patients, 70 pre-TEP patients. Age, sex, race, ISS, and RTS were similar between the groups. Mortality was lower in the TEP group but did not reach significance (57% vs 67%, p=0.079).

	TEP, n=69	Pre-TEP, n=70	p-value
Intra-op crystalloids, mean	4.9 liters	6.6 liters	0.009
1 <sup>st</sup> 24 hr FFP transfusion, mean	10.5	16.1	0.003
1 <sup>st</sup> 24 hr platelet transfusion, mean	3.0	7.6	<0.001
Unexpected survivors by TRISS (%)	14 (20.3 %)	4 (5.7 %)	0.01
Unexpected deaths by TRISS (%)	2 (2.9%)	12 (17.1%)	0.005

**Conclusions:** We have demonstrated that an exsanguination protocol, delivered in an aggressive and predefined manner, increases unexpected survivors and reduces unexpected deaths. In addition, intra-operative fluid requirements and overall blood product usage were also reduced following implementation of a TEP.

**REVIEW OF CURRENT BLOOD TRANSFUSIONS STRATEGIES IN A MATURE LEVEL I TRAUMA CENTER. WERE WE WRONG FOR THE LAST 60 YEARS?**

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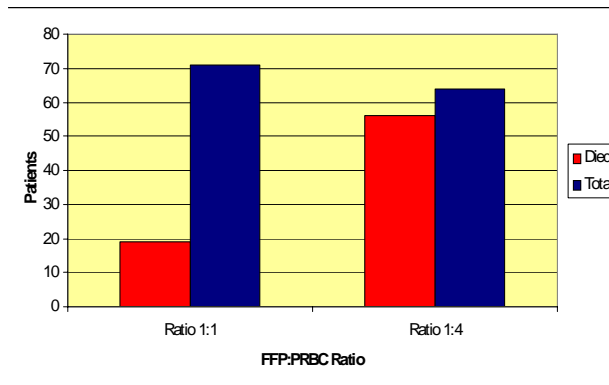
**Invited Discussant:** Peter Rhee, M.D., M.P.H.

**Background:** Recent military experience reported casualties who receive >10 units of PRBC in 24 hours have 20% vs. 65% mortality when FFP to PRBC ratio was 1:1 vs. 1:4, respectively. We hypothesize similar mortality outcomes in civilian trauma patients that require operative intervention.

**Methods:** Four year retrospective study of all trauma patients who underwent emergency surgery in an urban Level I Trauma Center. Patients were divided into two groups; those that received ? 10 or >10 units of PRBC after initial surgical intervention. The primary outcome measure between transfusion groups was the impact of initial FFP: PRBC ratio on mortality, variables included patient age, gender, mechanism and ISS.

**Results:** A total of 2,746 underwent surgical intervention. 1,985 (72.2%) received no transfusion, 626 (22.8%) received ? 10 units of PRBC and 135 (4.9%) >10 units of PRBC. There was no statistical difference in patient age, gender, mechanism or ISS between groups. For patients that received ? 10 units of PRBC there was no difference in mortality 62/611 (10.1%) vs. 2/15 (13.3%) when FFP: PRBC ratio was 1:1 vs. 1:4 (p: 0.65). Statistically significance difference in mortality was found in patients that received >10 units of PRBC 26% vs. 87.5% (p: 0.0001).

**Conclusion:** Attention to achieve a ratio of 1:1 FFP to PRBC is of the essence in patients transfused with >10 units of PRBC. New transfusion guidelines need to incorporate the potential benefit of whole blood into a massive transfusion protocol.





## SURVIVING BLOOD LOSS WITHOUT FLUID RESUSCITATION

Christian Shults MD, Elizabeth Sailhamer MD, Yongqing Li MD PhD, Baoling Liu MD, Spaniolas Konstantinos MD, Tabbara Malek MD, Elena Koustova PhD, George Velmahos MD\*, Marc de Moya MD, Hasan B. Alam MD\*, Harvard Medical School/Massachusetts General Hospital, Boston, MA

**Invited Discussant:** Carl J. Hauser, M.D.

**Objective:** We have previously shown that administration of histone deacetylase inhibitors (HDACI) enhances gene transcription through specific acetylation patterns of DNA associated histone proteins (“histone code”). Furthermore, it protects against organ damage when given *pre-hemorrhage*. This experiment was done to test whether administration of HDACI *after* lethal hemorrhage, without fluid resuscitation, would improve outcome by creating a pro-survival phenotype.

**Methods:** 72 Male Wistar-Kyoto rats (n=12/group) were subjected to volume-controlled hemorrhage over one hour (40% arterial bleed in 10 min + 20% venous bleed over 50 min). After hemorrhage, animals were randomized to receive one of two HDACI: 1) valproic acid (VPA; 300mg/kg), or 2) suberylanilide hydroxyamic acid (SAHA; 7.5 mg/kg). Control groups included: 3) no hemorrhage (sham), 4) no resuscitation (NR), 5) 0.9% saline resuscitation, (NS; 3x shed blood), 6) vehicle control (VEH). Hemodynamic data were recorded continuously, and physiologic parameters were measured serially. Survival for 180 minutes after hemorrhage was the primary endpoints. Acetylation of core histones in key organs was measured by Western blotting.

**Results:** Non-resuscitated shock was lethal in 75% of the animals (NR group). Administration of HDACI after hemorrhage (without fluid resuscitation) significantly increased histone acetylation, and improved 3-hour survival (75% and 83% in VPA and SAHA groups respectively,  $p < 0.05$  HDACI vs. NR). All of the sham and NS animals, and only 40% of the VEH animals survived.

**Conclusions:** This study demonstrates that post shock administration of HDACI can significantly improve survival in a highly lethal model of hemorrhagic shock, even in the absence of conventional fluid resuscitation. This approach may be especially relevant for austere environments where fluids are in limited supply, such as a battlefield.

**HSPTX ATTENUATES HEPATIC TRANSCRIPTION FACTOR ACTIVATION  
AND PRO-INFLAMMATORY MEDIATOR SYNTHESIS AFTER  
HEMORRHAGIC SHOCK**

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**Invited Discussant:** Eileen M. Bulger, M.D.

**Objective:** Recent studies have confirmed that the type of fluid used to restore perfusion after hemorrhagic shock can contribute to the propagation of inflammation and development of end organ injury. We have previously demonstrated attenuation of pulmonary and ileal inflammation after ischemia-reperfusion injury when Hypertonic saline and Pentoxifylline (HSPTX) were administered in combination as a resuscitative fluid. We hypothesized that the decrease in hepatic injury observed with HSPTX is associated with attenuation of iNOS activity and pro-inflammatory mediator production when compared to Ringer's lactate (RL) in vivo.

**Methods:** In a standard model of hemorrhagic shock, male Sprague-Dawley rats were resuscitated with racemic RL (32 ml/kg) or HSPTX (4 ml/kg 7.5% NaCl + PTX 25 mg/kg). Liver and plasma samples were collected 4 and 24 hours after resuscitation. Liver injury was determined by histology and plasma AST and ALT levels. Total Hepatic nitrite, TNF- $\alpha$ , IL-1 $\beta$ , and IL-6 were measured with ELISA. HMGB1, iNOS, NF $\kappa$ B phosphorylation, and STAT3 phosphorylation, were determined by Western blot.

**Results:** RL resuscitation led to statistically significant increases all measured parameters when compared to the negative control. In contrast, HSPTX did not induce elevations in histologic liver injury or ALT levels. HSPTX attenuated iNOS by 40% (P<0.01), nitrite by 25% (P<0.05), TNF- $\alpha$  by 25% (P<0.05), IL-1 by 63% (P<0.01), IL-6 by 35% (P<0.05), and HMGB1 by 30% (P<0.05) when compared to RL. Furthermore, HSPTX reduced cytoplasmic I $\kappa$ B $\alpha$  phosphorylation by 34% (P<0.05), nuclear NF- $\kappa$ B p65 phosphorylation by 75% (P<0.01), and STAT3 phosphorylation by 52% (P<0.01).

**Conclusion:** The reduction in liver injury observed with HSPTX resuscitation after hemorrhage is associated with attenuation of iNOS activity, transcription factor activation, and pro-inflammatory cytokine production. Therefore, HSPTX has the potential to be a superior resuscitation fluid with significant immunomodulatory properties.

**AGE OF TRANSFUSED BLOOD: AN INDEPENDENT PREDICTOR OF MORTALITY DESPITE UNIVERSAL LEUKOREDUCTION**

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**Invited Discussant:** Michael D. Grossman, M.D.

**Background:** Transfusion of old blood has been shown to be associated with an increased risk of post-injury multiple organ failure, infection, and prolonged hospital length of stay. This phenomenon may be mitigated by transfusion of leukoreduced red cell units. The purpose of this study was to determine the influence of the age of stored blood on outcome in trauma patients who universally received leukoreduced blood transfusions.

**Methods:** Patients admitted to a level I trauma center between 2000 - 2006 who received ≥1 unit of blood during the first 24 hours of hospitalization were selected for inclusion (n=1899). Patients who died within 24 hours of admission were excluded. Odds ratios (ORs) and 95% confidence intervals (CIs) were calculated for the association between mortality and the age and amount of blood transfused within the first 24 hours, adjusted for age, sex, injury severity, injury mechanism, number of units transfused, and length of stay.

**Results:** Among patients who received 1-2 or 3-5 units in the first 24 hours, no association between the age of transfused blood and mortality was observed. For patients who received 6-12 units, no association was observed with blood < 14 days old; however, transfusion of older blood was associated with a 2-3 fold increased risk of death.

	Total # of Units Transfused		
	1-2 Units	3-5 Units	6-12 Units
<b>0 – 14 Days Old</b>	<b>OR (95% CI)</b>	<b>OR (95% CI)</b>	<b>OR (95% CI)</b>
<b>0 Units</b>	Reference	Reference	Reference
<b>1-2 Units</b>	0.80 (0.35-1.86)	1.09 (0.47-2.54)	0.75 (0.29-1.92)
<b>&gt;2 Units</b>	NA	0.93 (0.26-3.36)	1.19 (0.53-2.71)
<b>&gt;14 Days Old</b>			
<b>0 Units</b>	Reference	Reference	Reference
<b>1-2 Units</b>	0.73 (0.31-1.70)	0.80 (0.32-2.03)	<b>2.80 (1.11-7.07)</b>
<b>&gt;2 Units</b>	NA	0.87 (0.24-3.16)	<b>3.61 (1.50-8.66)</b>

**Conclusions:** Among patients transfused 6-12 units of blood in the first 24 hours, transfusion of older blood is independently associated with mortality. This association was observed despite a practice of universal leukoreduction, suggesting the need for the development of alternative blood banking strategies for the trauma patient.

**PRESTORAGE LEUKOREDUCTION AMELIORATES THE EFFECTS OF AGING ON BANKED BLOOD**

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**Invited Discussant:** Walter Biffi, M.D.

**Background:** Prior studies have demonstrated that the transfusion of older blood is independently associated with higher rates of infectious complications, multiorgan failure, and mortality. Putative mechanisms implicate leukocytes in stored blood which generate increasing amounts of pro-inflammatory cytokines and lipid mediators as the stored blood ages. However, these studies were limited to the use of non-leukoreduced blood. The effect of the age of stored leukoreduced blood on clinical outcomes has not been previously described. The purpose of this retrospective cohort study was to describe the effect of prestorage-leukoreduction (PS-LR) on the detrimental effects of the age of blood products utilized in trauma patients.

**Methods:** Our trauma database was queried for all patients who received  $\geq 6$  units of packed red cells and survived  $\geq 48$  hours since 5/99 when PS-LR was begun. Total transfusion requirements and demographic data were collected. Blood bank records were reviewed to determine the age of each unit of blood transfused. Multivariate logistic regression was used to determine the relationship between the age of PS-LR blood transfused and mortality adjusting for total transfusion requirement, age, ISS, Head AIS, mechanism, hospital length of stay, and gender.

Mean age of blood	OR	95% CI
>14 days	0.43	0.18-0.99
>21 days	0.44	0.23-0.86
14-21 days*	0.66	0.25-1.77
>21days*	0.33	0.14-0.81

\*reference 0-14 days

**Results:** A total of 399 patients, receiving 6,603 units of blood, met inclusion criteria. When considering mean age of blood as a continuous variable, the multivariate logistic regression model demonstrated a 4% reduction in mortality risk per day of unit age (OR: 0.96, CI: 0.92-0.99). Increasing mean age of blood remained an independent predictor of decreased mortality when analyzed as a dichotomous variable (>14 days and >21 days) as well as when referenced to units aged 0-14 days. The ROC for the model demonstrated an AUC of 0.90.

**Conclusion:** The deleterious effects of aging on banked blood are ameliorated by prestorage leukoreduction.

**REMOVAL OF ERYTHROPOIETIN FROM ANEMIA TRAUMA PRACTICE  
GUIDELINE DOES NOT INCREASE RED BLOOD CELL TRANSFUSIONS  
AND DECREASES HOSPITAL UTILIZATION COSTS**

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**Invited Discussant:** Ed Childs, M.D.

**Objective:** We previously showed that utilization of erythropoietin (EPO) failed to produce significant reduction in blood utilization in trauma patients. We undertook this study to analyze blood utilization since EPO removal from our trauma service anemia practice management guideline one year ago.

**Methods:** Electronic records of patients admitted to the trauma service were retrospectively reviewed for units of packed red blood cells transfused (pRBCs) and for units of EPO administered 12 months prior to the initiation of an anemia practice guideline (PRE), 12 months during the practice of this anemia guideline (GUIDE), and 12 months following the removal of EPO from the guideline (POST). Hospital utilization cost (Rx Cost) was also reviewed for the respective time periods.

**Results:** Data in Table 1 and Table 2 are expressed as mean ( $\pm$ SD). ANOVA was utilized for statistical analysis and  $p < 0.05$  was significant.

**Table 1.**

	PRE (N=1446)	GUIDE (N=1586)	POST (N=1849)	P value
Age	33.7 (18.2)	34.5 (18.1)	39.3 (17.6)	NS
ISS	11.9 (10.2)	13.2 (10.4)	13.1 (10.6)	P<0.0001
LOS	7.2 (10.6)	7.1 (11.0)	7.5 (12.1)	NS
ICU Days	2.5 (6.0)	2.8 (6.9)	2.7 (6.3)	NS
pRBC (units)	1.8 (6.0)	1.4 (4.8)	1.3 (5.5)	NS
EPO (total doses)	228	410	50	<0.0001
Rx Cost	\$102,600	\$184,500	\$22,500	

**Table 2.**

	PRE (N=50)	GUIDE (N=51)	POST (N=71)	P value
Age	46.0 (19.1)	43.3 (16.1)	45.1 (15.3)	NS
ISS	23.2 (14.7)	21.7 (13.2)	21.8 (11.2)	NS
LOS	37.8 (16.7)	38.6 (20.3)	38.4 (21.3)	NS
ICU Days	21.4 (11.2)	21.6 (13.7)	19.2 (12.7)	NS
pRBC (units)	5.0 (4.2)	4.9 (9.2)	4.1 (5.4)	NS
EPO (total doses)	95	160	33	<0.0001

**Conclusion:** Removal of erythropoietin from our trauma service anemia practice management guideline did not result in increased blood utilization. However, it did yield a hospital utilization cost savings of \$162,000.

**LET THE SURGEON SLEEP: TRAUMA TEAM ACTIVATION FOR SEVERE HYPOTENSION**

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**Invited Discussant:** Suresh K. Agarwal, Jr., M.D.

**Objective:** Trauma Centers must balance the need to bring the full resources of the trauma center to the sickest patients with the need with personnel resource allocation. Our level 1 academic trauma center changed the systolic blood pressure (BPs) requirement for trauma team activation (TTA) from 90 to 80 mmHg. This investigation was undertaken to determine the effects of such change.

**Methods:** The hospitals trauma registry identified patients for two 18 months periods, pre and post the change in TTA criteria. Data elements included team activation level, Emergency Department (ED) LOS, ED to Operating Room (OR) times, delay to OR and Injury Severity Score (ISS).

**Results:** Full TTA decreased as did the percentage of cases with TTA. Eleven patients were identified in the BPs < 80 group who would have had TTA prior to the change. All eleven had timely trauma surgery consults. No delays to OR were related to TTA. The percentage of cases with laparotomy occurring more than 2 hours after arrival was unchanged. One hundred and ninety fewer TTAs were called in an 18 month period. In-patient mortality between the two groups was not significantly changed.

**Conclusions:** Changing criteria for TTA from BPs 90 to < 80 preserves personnel without patient harm. Lowering the systolic blood pressure for trauma team activation is one method of preserving trauma surgery manpower.

	<b>Pre (BPs &lt;90)</b>	<b>Post (BPs &lt;80)</b>	<b>Difference</b>
<b>Total TTA</b>	348	224	-190
<b>% of TTA</b>	17.8%	12.16%	p< 0.0001
<b>ISS of TTA pts.</b>	22.96	28.57	p = 0.00018
<b>BPS 80-90 mmHg (no other criteria for TTA)</b>	8	11	p = 0.09
<b>Major abdominal operation &gt; 2 hr</b>	23 of 91	11 of 53	P = 0.538

## MALPRACTICE RISK: TRAUMA CARE VERSUS OTHER SURGICAL AND MEDICAL SPECIALTIES

Gerald McGwin Jr. MS PhD, Donald Reiff MD, Patricia Pritchett JD, Jeannine Bailes, Loring W. Rue III MD\*, University of Alabama at Birmingham Health System, Birmingham, AL

**Invited Discussant:** Ronald M. Stewart, M.D.

**Background:** Medical malpractice has been noted to play an important role in physicians' decisions to pursue or remain in certain high-risk specialties such as trauma, despite little evidence suggesting an elevated malpractice risk. The objective of this study was to compare malpractice risk among trauma patients compared to patients treated by other medical and surgical specialties at an academic medical institution.

**Methods:** Information regarding all legal claims filed between 2003 and 2006 at an academic medical institution, including the department/service primarily involved, the current medical-legal disposition of the claim, and the actual or expected expenses, among other characteristics, was obtained. The number of patients admitted to each department/service during this period was also obtained. The number of claims per 10,000 patient days was calculated for each department/service and compared.

**Results:** Among the 13 medical and surgical specialties considered trauma had the lowest number of claims per 10,000 patient-days; it was ranked 10<sup>th</sup> on a strictly per capita basis. Trauma also had the lowest cost per patient-day; it was ranked 9<sup>th</sup> on a per capita basis.

**Conclusions:** At a single academic institution, trauma care had the lowest number of legal claims per length of stay. These results fail to support perceptions that trauma care is associated with an increased malpractice risk compared to other specialties. Though these results are subject to certain limitations, they are important for increasing and maintaining the ranks of surgeons providing trauma care.

	Claims	Patient Days	Claims/10,000 Pt. Days
Service A	2	2,224	8.99
Service B	4	5,996	6.67
Service C	8	13,029	6.14
Service D	21	40,179	5.22
Service E	19	38,084	4.99
Service F	16	34,708	4.61
Service G	32	80,306	3.98
Service H	10	34,025	2.94
Service I	22	75,579	2.91
Service J	3	13,617	2.20
Service K	38	248,644	1.53
Service L	9	76,597	1.17
<b>Trauma</b>	10	94,892	1.05

**CTA-BASED SCREENING REDUCES TIME TO DIAGNOSIS AND STROKE RATE IN BLUNT CERVICAL VASCULAR INJURY**

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**Invited Discussant:** Ronald D. Robertson, M.D.

**Introduction:** Advances in computed tomography capabilities have enabled trauma surgeons to screen for and diagnose the severity of blunt cervical vascular injury (BCVI) using CTA alone. We hypothesized that the use of CTA-only screening and diagnostic methods, compared to previous catheter arteriogram-based screening, would reduce the time interval from admission to diagnosis also reduce the stroke rates associated with these injuries.

**Methods:** All patients admitted to a level I trauma center after December 1999 at risk for BCVI were screened. Until March 2005, patients were screened with cervical catheter angiography (CA). Subsequently, a CTA-only screening/diagnostic program was initiated simultaneously with standardized interdisciplinary treatment protocols for BCVI. Data for controls were subsequently obtained by reviewing trauma registry records.

**Results:** Of 3012 trauma admissions from April 2005 through July 2006, 26 patients were found to have BCVI diagnosed by CTA alone. A standardized, injury grade-based treatment protocol was then initiated immediately based upon CTA findings. Time to diagnosis and stroke rate in these patients were then compared to 79 patients found to have BCVI from December 1999 to March 2005 during CA-based screening. There were no differences in sex, mean age, ISS, head/neck AIS, or arrival GCS between the CA and CTA groups. With CA-based screening, the mean±SD time from trauma center admission to diagnosis was 31.2±41.1 hours. After transition to CTA screening in Mar 05, this time was reduced to 2.65±3.3 hours ( $p<.001$ ). During the era of CA-based screening, the overall stroke rate for BCVI at our institution was 15.2% ( $n=12/79$ ). Following the initiation of CTA-based screening, the stroke rate was reduced to 3.8% ( $n=1/26$ ,  $p=.046$ ).

**Conclusions:** The initiation of a CTA-based screening and diagnostic program, along with interdisciplinary standardized treatment protocols, reduced the time to diagnosis of BCVI twelve-fold and the institutional stroke rate due to BCVI four-fold. This may be due to earlier diagnosis and initiation of definitive therapy.



**CT ALONE FOR CERVICAL SPINE CLEARANCE IN THE UNRELIABLE PATIENT - ARE WE THERE YET?**

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**Invited Discussant:** James W. Davis, M.D.

**Objective:** Injuries to the cervical spine (CS) occur in 2-6.6% of blunt trauma patients. Some studies have suggested that computed tomography (CT) alone is sufficient for CS clearance in unreliable patients based on follow up magnetic resonance (MR) imaging not altering management. We hypothesized that an admission cervical spine CT with no acute injury - using new CT technology - is not sufficient for CS clearance in an unreliable patient.

**Methods:** The trauma registry was used to identify all patients with blunt trauma that had CS imaging with a CT and MR between August 2004 and December 2005. During this time period, a clinical guideline was in place whereby patients who had persistently unreliable exams had MR despite a normal admission CT. Medical records were reviewed for demographics, Glasgow Coma Score (GCS) at time of MR, and injury specific data.

**Results:** 734 patients in total were identified. 205 patients without obvious neurological deficits but unreliable clinical exams, defined by a GCS of  $\leq 14$ , had an initial cervical spine CT read by an attending trauma radiologist as having no acute injury. Mean age was 42.4 years ( $\pm 20.4$ ) and mean ISS was 28.9 ( $\pm 11.8$ ). There were 136 (66.3%) males.

Mechanism of injury included; motor vehicle/motorcycle collision (48.8%), fall (25.4%), pedestrian struck (10.2%), assault (7.8%), and other (7.8%). 187 (91.2%) patients had a negative MR and collars were subsequently removed. After collar removal, no patient developed new neurological deficit. 17 (8.3%) patients had an abnormal MR, 4 of which required operative repair and the remaining 13 required extended cervical collar use. One patient had a suboptimal MR and was discharged in a collar with scheduled follow-up.

**Conclusion:** Newer generation CT continues to miss CS injuries in unreliable patients. MR changed the management in 8.3% of patients having had an admission CT with no acute injury. Thus, we recommend continued use of MR for CS clearance in the unreliable patient and ongoing evaluation as the quality of CT imaging continues to evolve.

**OPTIMAL MANAGEMENT STRATEGY FOR INCIDENTAL FINDINGS IN TRAUMA PATIENTS: AN INITIATIVE FOR MID-LEVEL PROVIDERS**

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**Invited Discussant:** Blaine L. Enderson, M.D.

**Introduction:** Increasing patient volume and residents' work hour restrictions have imposed stress on the workload at trauma centers. Comprehensive tertiary surveys are time consuming, as are appropriate follow-up plans for incidental findings. As such, mid-level providers (MLP) can help streamline this process. Herein, we initiated a care plan where MLP's conducted all tertiary surveys, and coordinated follow-ups for incidental findings.

**Methods:** From 11/2005 to 5/2006, MLP's performed tertiary surveys on all trauma patients within 48 hours of admission. Tertiary surveys consisted of a complete history and physical, radiographic evaluations and appropriate consultations. Incidental findings were recorded. A follow-up plan was devised, and the course of action documented. Patients or family members were informed, and their acknowledgements were filed. Data included mechanism of injury, patient demographics, injury severity score (ISS), incidental findings and the course of action. Data are presented as mean  $\pm$  SE.

**Results:** During the 6-month study period, there were 1,027 patients admitted. Blunt mechanisms accounted for 81% of the injuries, primarily consisting of motor vehicle crash and fall. The mean age was  $51.8 \pm 2.1$  years, and mean ISS was  $18.5 \pm 1.4$ . There were 76 patients with 87 incidental findings (7.4%), 53 were males. Incidental findings of clinical significance consisted of 18 pulmonary nodules or neoplasm, 9 adrenal masses ( $> 4$  mm size), 7 patients with lymphadenopathy, 5 benign cystic lesions and 3 renal masses. Other neoplastic lesions included bladder (2), thyroid (2), ovarian (1), breast (1) and rectal (1). Other category was comprised of calculi and chronic vascular abnormalities.

**Discussion:** In the era of medicolegal pressure, coupled with restricted residents' work hours, a MLP-initiative to streamline the tertiary survey can effectively address incidental findings, which can be clinically significant. This MLP-driven care plan will reduce the residents' workload, provide appropriate follow-up, and minimize legal risks inherent to incidental findings on the trauma service.

**FOUR YEARS OF AN AGGRESSIVE PROPHYLAXIS AND SCREENING  
PROTOCOL FOR VENOUS THROMBOEMBOLISM IN A LARGE TRAUMA  
POPULATION**

Raeanna Adams, MD; Robert Gatliff, MD; Miller Hamrick, MD; Christina Berenguer, MD; M. Gage Ochsner, MD\*; Christopher Senkowski, MD\*, Memorial Health University Medical Center, Savannah, GA

**Invited Discussant:** Abe Fingerhut, M.D.

**Purpose:** This retrospective review of a prospectively collected database was conducted to determine the efficacy of four years of an aggressive screening and prophylaxis protocol for venous thromboembolism (VTE) in a large trauma population.

**Methods:** From Oct 2002 to Sept 2006, high-risk trauma patients received prophylaxis with both lower extremity (LE) mechanical compression and low molecular weight heparin after admission and were followed with weekly LE duplex ultrasound studies. Data were acquired from the trauma registry for patients with length of stay (LOS) >2 days and adjunctive chart review conducted in all patients with VTE.

**Results:** Over 4 years, 2,939 patients were admitted to the Trauma service with LOS >2 days. Overall rates for deep venous thrombosis (DVT) and pulmonary embolus (PE) were 2.5% and 0.7%. High risk criteria of closed head injury, spinal cord injury, LE fractures, and pelvic fractures were present in 89% of VTEs. Duplex ultrasound was performed in 982 patients, 9% with DVTs. Notably, 85% of LE DVTs were found on screening duplex.

N	% High Risk	% DVT		% PE	
		<i>Low risk</i>	<i>High risk</i>	<i>Low risk</i>	<i>High risk</i>
<b>LOS &gt;2d 2939</b>	26	0.6	7.8	0.2	2.3

**Conclusions:** Routine use of both mechanical compression and pharmacologic prophylaxis in patients meeting defined high risk criteria leads to a very low incidence of VTE when compared to the literature. All patients with VTEs were identified as high risk by our expanded criterion, and the weekly screenings revealed multiple DVTs clinically silent at the time of diagnosis. The use of weekly screening duplexes in this large group provides the denominator to confirm the efficacy of an aggressive approach.

## INCREASED MORTALITY ASSOCIATED WITH THE EARLY COAGULOPATHY OF TRAUMA IN COMBAT CASUALTIES

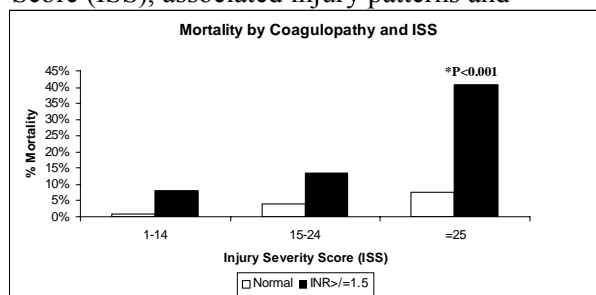
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**Invited Discussant:** Anna M. Ledgerwood, M.D.

**Introduction:** Recent civilian studies have documented a relationship between increased mortality and the presence of coagulopathy diagnosed in the ED. We hypothesized that acute coagulopathy (INR  $\geq$  1.5) in combat casualties is associated with increased injury severity and mortality as is seen in civilian trauma.

**Methods:** A retrospective study of combat casualties who received a blood transfusion at a single combat support hospital between September 2003 and December 2004 was performed. Coagulation status, pH, and temperature were recorded on arrival to the ED. These were analyzed by Injury Severity Score (ISS), associated injury patterns and mortality.

**Results:** 3442 patients were seen at the combat support hospital during the study period. 391 patients met study criteria, and 347 had coagulation data. The prevalence of



acute coagulopathy measured within minutes of arrival in the ED was 38%. The prevalence of mortality by coagulopathy increased as ISS increased (see fig).

Coagulopathy and acidosis were associated with mortality, OR of 6.3 and 6.9 (95%CI 2.1-19.5), respectively, while temperature did not affect outcomes (OR 1.1, 95% CI 0.4-2.6). Mortality in those who were coagulopathic on arrival to the ED was 24% (32/133) vs. 4% (8/214) in those not presenting with coagulopathy ( $p < 0.001$ ).

**Conclusions:** The early coagulopathy of trauma is readily diagnosed in the ED, and present in over 1/3 of combat casualties. Coagulopathy, independent of hypothermia and acidosis, is associated with increased ISS and mortality in combat casualties, similar to civilian trauma studies. Early diagnosis and treatment of acute traumatic coagulopathy with new resuscitation paradigms may improve outcomes.

**RANKING OF TRAUMA CENTER PERFORMANCE: THE BARE ESSENTIALS**

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**Invited Discussant:** Frank L. Mitchell, III, M.D., M.H.A.

**Introduction:** Evaluation of trauma center (TC) performance has been limited to comparisons of observed versus expected mortality using TRISS methodology. Few studies have focused on identifying top performers. In part, this is due to the perceived need for extensive data collection to adequately risk adjust. To mitigate these concerns, we sought to identify the key factors accounting for differences in case mix and assessed their impact on rankings of hospital performance.

**Methods:** 190 TC contributing data to NTDB over 2004-2005 were used for hospital rankings (169,929 patients (ISS $\geq$ 9). TC were ranked by crude mortality. We then added variables (ISS, blood pressure (SBP), mechanism, age, gender, comorbidities, body region AIS) singly to a risk adjustment model to obtain adjusted probability of death. TC were then ranked again. The variable that affected rankings the greatest was kept; the process was repeated in an iterative fashion until the incremental change in ranks was minimal.

**Results:** ISS accounted for the most variation in mortality rates across TC, shown by the large rank change with addition of ISS to the model (Table). Specifically, when ISS was taken into consideration, 92% of TC changed their rank by  $\geq$ 3 and almost half their quartile rank by at least 1. In lesser order of importance, age, SBP, head AIS, mechanism, gender, and abdominal AIS were relevant to adjust for case mix.

	Crude+	+	+	+Head	+	+	+ Abd
	ISS	Age	SBP	AIS	Mechanism	Gender	AIS
% Rank change $\geq$ 3	92	83	82	76	63	15	1.5
%Rank change $\geq$ 1 quartile	49	27	22	14	8	2	1

**Conclusion:** TC rankings are affected by few parameters, reflecting their relationship to mortality and their relative frequencies. Complex risk adjustment methodology is not critical to identify top performers. Data abstraction for the purpose of comparing TC performance should focus on ensuring that at minimum, these variables are collected with a high degree of accuracy.

**PATIENT SAFETY IN TRAUMA: MAXIMAL IMPACT MANAGEMENT  
ERRORS AT A LEVEL I TRAUMA CENTER.**

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**Invited Discussant:** Erik W. Streib, M.D.

**Objective:** To identify patterns of management errors with maximum impact (death) in a Level I trauma center.

**Methods:** A critical analysis of all trauma deaths. Errors were classified as per National Quality Forum Patient Safety Net Taxonomy.

**Results:** There were 827 (4.4%) deaths among 18,983 admissions (2001-2006). 739 records were available for review. 75 (10.1%) of deaths had 79 errors in management that were seen in all ISS groups (<15:17.9%;16-24: 15.8% ; >25: 16-24:7.6% ).

<i><b>ERROR TYPE &amp; PHASE</b></i>	<i><b>ERROR DOMAIN</b></i>	<i><b>ERROR CAUSE</b></i>
Airway : Inability to secure (20 events)	Pre-hospital 16; ED1; ICU 3	Judgment, Execution
Hemorrhage control , Resuscitation (23 events)	ED11*, Delay to angio (4) or OR (2), Poor OR care (6)**,	Judgment, Execution, Systems
Post-operative care (25 events)	PACU and ICU ***	Judgment, Systems, Communication
Missed Injuries (11 events)	# ED/ ICU 9; OR 2	Judgment

*\* and \*\* Transport to CT of unstable patients ; poor resuscitation in ED and OR ; \*\*\* airway issues, absent DVT prophylaxis, delayed diagnosis of bowel gangrene, poor ICU care of the elderly, delayed treatment of coagulopathy, hyperkalemia, bowel leak, pneumonia etc; # duodenum, aorta, blunt small bowel injury, subdural hematoma etc.*

**Discussion:** Our results are identical to those of other mature systems (Gruen al, Ann Surg 2006). Despite established guidelines, >90% were input and intention errors that lead to incorrect judgment , diagnosis and treatment .Improper communication and execution in these time-sensitive situations resulted in preventable deaths that were mostly provider-related.

**Conclusion:** Provider failures persist even in mature trauma systems. Emphasis on management guidelines is not enough. Future patient safety goals must focus on outcome rather than process and enhance system resilience by integrated trauma management and optimized trauma team dynamics (Mackersie and Rhodes, Surgical Patient Safety, 2005).

**HAZARDS OF BENCHMARKING COMPLICATION RATES WITH THE NATIONAL TRAUMA DATA BANK: NUMERATORS IN SEARCH OF DENOMINATORS**

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**Invited Discussant:** John R. Clarke, M.D.

**Background:** Complication rates after trauma may serve as important indicators of quality of care. Meaningful performance benchmarks for complication rates require reference standards from comprehensive and systematically collected data. We examined the suitability of the NTDB as a reference for benchmarking trauma center complication rates.

**Method:** We selected the 5 most common complications in the NTDB v. 6.1. We used chi-square to compare three rates for each complication using three different denominators.

A) All patients from all 700 reporting facilities as the denominator (n=1,466,887)

B) Only patients from the 441 hospitals reporting at least one complication (n=1,307,729)

C) Patients from hospitals reporting at least one occurrence of each specific complication, giving a unique denominator for each complication (n range = 869,675 to 1,167,384).

**Results:** There was a 12.2% increase in the rate of each complication when patients from facilities not reporting any complications were excluded from the denominator (p < 0.001). When rates were calculated using a unique denominator for each complication, rates increased 25%-70%, (increase A to C, all p < 0.001) and produced a new rank order for the top 5 complications.

	Frequency	Rate A %	Rate B %	Rate C % (n=denominator)	Increase A to C
Any Comp	64,270	4.381	4.915	n/a	n/a
Pneumonia	18,207	1.241	1.392	1.559 (n=1,167,384)	25.6 %
UTI	14,818	1.010	1.122	1.391 (n=1,065,433)	37.7 %
ARDS	6,328	0.431	0.483	0.576 (n=1,098,257)	33.6 %
DVT	5,610	0.382	0.428	0.536 (n=1,047,594)	40.3 %
MI	5,192	0.350	0.393	0.597 (n=869,675)	70.6 %

**Conclusion:** There is great variability in complication data reported in the NTDB. This creates a challenge for appropriately abstracting and interpreting information, especially for performance benchmarking. We recognize the value of the information in large registries, but assert that investigators must take care when selecting appropriate numerators and denominators for their analyses to ensure validity.

**MEASUREABLE OUTCOMES OF QUALITY IMPROVEMENT IN THE  
INTENSIVE CARE UNIT**

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**Invited Discussant:** Christopher P. Michetti, M.D.

**Introduction:** The use of “care bundles” in the prevention of ventilator-associated pneumonia (VAP) and other intensive care unit (ICU) complications have been increasingly utilized in critical care practice. However, the effective implementation of these strategies represents a challenge in a busy Level I Trauma ICU. We devised a daily “Quality Rounds Checklist” (QRC) tool for use in the ICU to increase compliance with these prophylactic measures and identify areas for improvement in quality of care.

**Methods:** A prospective before-after design was utilized to examine the effectiveness of the QRC tool in documenting compliance with 16 prophylactic measures for VAP, deep venous thrombosis / pulmonary embolism, central line infection and other ICU complications. Areas for daily improvement were acted upon in a real-time fashion by the ICU fellow. Monthly compliance rates were assessed by a multi-disciplinary team for development of effective strategies for further improvement. Subsequent compliance and outcomes changes were then assessed over the initial three months of tool use.

**Results:** The QRC tool facilitated improvement of all measures not already at >95% compliance. Compliance with VAP bundle measures of head of bed elevation > 30 degrees (35.2% vs. 84.5%), sedation holiday (57.8% vs. 86.0%), and prophylaxis for both peptic ulcer disease (74.2% vs. 92.3%) and deep venous thrombosis (91.2% vs. 92.8%) were all increased. Resulting decrease in mean central line day (5.37 vs. 2.02) and ventilator day (7.53 vs. 2.98) was subsequently noted. Additionally, a decrease in mean monthly rates per 1000 device days of VAP (16.26 vs. 8.87), central line infection (11.30 vs. 5.76) and self extubation (7.78 vs. 2.24) was demonstrated.

**Conclusion:** Introducing a daily QRC tool facilitates improved compliance rates for a variety of clinically significant prophylactic measures in a busy Level I Trauma ICU. The daily use of this tool, requiring just a few minutes per patient to complete, equates to sustainable improvement in patient outcomes.



**TRAUMA TRAINING IN SIMULATION: TRANSLATING SKILLS FROM SIM-  
 TIME TO REAL-TIME**

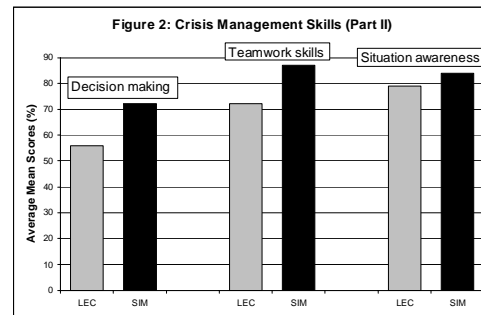
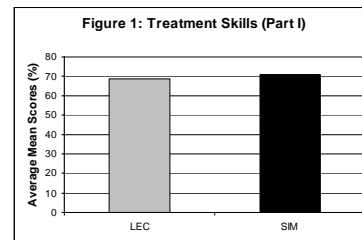
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**Invited Discussant:** Mark W. Bowyer, M.D.

**Objective:** To test the hypothesis that surgical residents receiving a simulation-enhanced curriculum will demonstrate superior crisis management skills during trauma resuscitations compared to residents who received the same curriculum in didactic sessions.

**Methods:** A 5-part scenario-based trauma curriculum was developed. To date, 17 residents have been randomized to either lecture-based (LEC) or patient simulator-based (SIM) training. The first 4 major trauma resuscitations performed by 11 residents (44 total) were taped and graded by 2 independent judges who were blinded to training method, using a specifically designed assessment tool incorporating both initial trauma evaluation/treatment skills (Part I) and crisis management skills (Part II). Summaries are presented for the average grade of the two judges, using repeated measures analysis to estimate the effect of training.

**Results:** The residents had nearly identical average scores on a post-training written test. Mean scores (expressed as percent of total score/ highest possible score per scenario) in Part I of the evaluation also appeared similar (Figure 1). In Part II, SIM trained residents scored higher in teamwork skills and decision making (Figure 2). See table for results of repeated measures modeling.



Area	Estimate	95% C.I.	p-value
Treatment skills	2.9	-12.0 to 17.8	0.70
Teamwork	14.1	-3.2 to 31.5	0.11
Decision-making	18.8	-7.9 to 45.5	0.17
Situation Awareness	5.6	-3.2 to 14.4	0.21

**Conclusions:** A curriculum incorporating simulation shows promise in developing crisis management skills that are essential for evaluation of critically injured trauma patients.

**RESEARCH: QUESTIONS AND ANSWERS FROM ACADEMIC TRAUMA SURGEONS**

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**Invited Discussant:** Basil A. Pruitt, Jr., M.D.

**Objective:** The impact of recent social and professional influences on trauma research is unclear. This study characterizes current research practices, opinions on research quality and barriers to academic productivity, expressed by academic trauma surgeons.

**Methods:** A survey tool was administered electronically to members of an academic trauma society. Questions on demographics, current and past research experience, perceptions of research quality trends and barriers to academic success were included.

**Results:** Response rate was 40% (322/815). The mean age of respondents was 45 with 73% reporting completion of a critical care fellowship and 63% practicing in a university setting. Recent participation in multi-institutional research was reported by 63%. The vast majority agreed or strongly agreed that both basic science (75%) and clinical (82%) research have become more difficult to perform. Greater difficulty in obtaining funding from their institutions was reported by 69% and by 61% for industry or private sources. Approximately 70% agreed that IRB regulations, confidentiality and consent requirements have impeded their research efforts while 86% agreed that increasing clinical requirements have inhibited their research efforts. Factors seen as impeding multi-institutional research, in order, were: funding, IRB issues, poor coordination, commitment of investigators and logistics. Personal motivation to perform research was reported to be diminished by 39% and not diminished by 61%. Perceived barriers to a successful research career were: insufficient protected time (42%), funding (25%), personal motivation (11%) and IRB issues (11%). Half of respondents agreed there is a trend of decreasing quality in presented research over the past 5 years. For the same period, 73% of respondents reported their number of peer-reviewed publications to be decreased or unchanged while 81% reported the same trend for their submission of grant proposals .

**Conclusion:** Research is overwhelmingly viewed as being more difficult to conduct. The primary barriers to research productivity are perceived to be decreased protected time, decreased funding availability and increased regulatory requirements.