

DAMAGE CONTROL RESUSCITATION INCREASES THE RISK OF THROMBOTIC COMPLICATIONS IN TRAUMA PATIENTS

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Invited Discussant: David Wisner, MD

Introduction: Damage control resuscitation (DCR) improves survival after hemorrhagic shock. However, the thrombotic complications of DCR are unknown. We evaluated the impact of DCR on the incidence of venous thromboembolic disease (VTE) in trauma patients.

Methods: DCR (administration of fresh frozen plasma [FFP], packed red blood cells [PRBC] and platelets in a fixed ratio) was implemented at our Level I trauma center in 4/2007. The records of patients admitted from 4/2007-4/2011 were reviewed. All patients received venous duplex surveillance of the lower extremities, and deep venous thrombosis (DVT) prophylaxis was administered according to American College of Chest Physician guidelines (ACCP-G). Demographics, injury data, VTE-risk factors and units of PRBC and FFP transfused within 24 hours of admission were recorded. Patients were stratified for VTE risk by ACCP-G and grouped by intent-to-treat (DCR vs. Non-DCR). Endpoints were lower-extremity DVT, symptomatic upper-extremity DVT, and symptomatic pulmonary embolus. The association of DCR and VTE was evaluated.

Results: A total of 1,838 patients were at high risk for VTE and were included for analysis. VTE and DVT events were significantly more likely in DCR patients (Table). Compared to Non-DCR, DCR patients were significantly younger, more likely to suffer blunt trauma, had a higher Injury Severity Score and lower initial systolic blood pressure. Following adjustment for these and other VTE-risk factors, DCR remained an independent predictor of VTE events (OR=1.72, 95% CI: 1.22-2.65).

	DCR (n=198)	Non-DCR (n=1640)	p
Patients with VTE	45 (23%)	166 (10%)	<0.01
Above-Knee DVT	17 (8.6%)	61 (3.7%)	<0.01
Below-Knee DVT	30 (15.2%)	109 (6.7%)	<0.01
Upper-Ext. DVT	8 (4.0%)	17 (1.0%)	<0.01
Pulmonary Embolus	2 (1.0%)	21 (1.3%)	0.731

Conclusion: DCR significantly increases the risk-adjusted rate of VTE events in trauma patients despite standard prophylaxis. The increased risk of thrombotic complications highlights the need to reserve DCR for selected patients.

BLOOD TRANSFUSION IN YOUNG WOMEN RESULTS IN EXCESS MORTALITY FOLLOWING TRAUMA

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Invited Discussant: Laura Moore, MD

Background: Gender and sex hormones have been shown to play important roles in response to inflammatory conditions such as traumatic injuries. This is particularly important as it relates to multi-organ failure and ultimately mortality following trauma. Gender discrepancies have been described for outcomes following transfusions across several chronic medical conditions. However it is unclear how gender across a spectrum of age ranges impacts outcomes in trauma patients requiring blood transfusions.

Methods: Retrospective review of blunt trauma patients aged ≥ 18 years admitted to a level 1 trauma center. Charts were reviewed for age, gender, Injury Severity Score, all blood transfusions required, and outcomes including mortality. Independent models were selected both for men and women as well as with respect to total quantity of units of blood transfused and whether they received fewer than 3 units packed Red Cells ($<3U$) versus 3 or more units ($3+U$). Logistic models were used to determine risk of mortality as a function of age, sex and number of units of blood transfused.

Results: For the total population of 3,482 patients each additional unit of blood transfused was associated with an increased risk of death ($OR=1.05(95\%CI=1.03-1.08)$). However, in a covariate model, there was a 3 way interaction between age, sex and number of units transfused indicating a synergistic relation ($p=0.0148$).

Comparing $3+U$ versus $<3U$ in men, the risk of death remained stable over increasing age groupings: 20yr old $OR=2.57$ ($95\%CI=1.03-6.46$), 30yr old $OR=2.53$ ($95\%CI=1.19-5.36$), 50yr old $OR=2.45$ ($95\%CI=1.53-3.92$), 70yr old $OR=2.37$ ($95\%CI=1.55-3.61$) and 90yr old $OR=2.29$ ($95\%CI=1.19-4.40$). However, unlike men, the risk of death comparing $3+U$ to $<3U$ was dramatically elevated in younger women as compared to older women: 20yr old $OR=27.4$ ($95\%CI=7.91-94.96$), 30yr old $OR=18.47$ ($95\%CI=6.57-51.92$), 50yr old $OR=8.33$ ($95\%CI=4.29-16.39$), 70yr old $OR=3.81$ ($95\%CI=2.25-6.42$), and 90yr old $OR=1.73$ ($95\%CI=0.83-3.60$). Thus with increasing age, the effect upon mortality of additional blood transfusions approached parity across genders.

Conclusions: Overall, requiring 3 or more units of blood was associated with increased risk of mortality. Whereas there was a marked gender difference in the effect of increasing blood transfusion upon mortality of younger women, this effect was no longer evident with ages above 50 years old. We postulate that estrogen mediated responses may influence the impact of blood transfusions for young female trauma patients.

**SIRT-1 TARGET PROTEIN ACETYLATION IS BLUNTED BY
ADMINISTRATION OF RESVERATROL FOLLOWING
ISCHEMIA-REPERFUSION INJURY**

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Invited Discussant: Hasan Alam, MD

Introduction: Hypoxic injury and oxidative stress associated with hemorrhagic shock and resuscitation (HSR) leads to cellular damage and multiple organ dysfunction. Sirtuin-1 (Sirt-1) is a key metabolic intermediary that regulates stress responses, inflammation, and apoptosis via acetylation/de-acetylation of transcription factors such as the inflammatory mediator, Nuclear Factor- κ B (NF κ B), and the apoptosis initiator, p53. Suppression of Sirt-1 activity in sepsis can be reversed with administration of the antioxidant resveratrol, a Sirt-1 agonist. The aims of this study were to determine if Sirt-1 expression is altered following HSR and if resveratrol affects Sirt-1 activity following hypoxic stress.

Methods: *In vivo*: Hemorrhagic shock was achieved in male Sprague-Dawley rats by arterial blood withdrawal to mean arterial pressure (MAP) of 25 ± 5 mmHg for 1-Hr prior to resuscitation. Hepatic tissue was stained and blind scored for relative Sirt-1 expression. *In vitro*: Primary hepatocytes were isolated from male Sprague-Dawley rats ($\geq 95\%$ purity, $\approx 97\%$ viability). Cells were allowed to adhere in culture (3-Hrs) prior to 6-Hrs hypoxia (HYP) ($\text{CO}_2 \geq 10\%$) in the absence or presence of resveratrol (RES; $75\mu\text{M}$). Cell lysates were collected in RIPA buffer and immunoprecipitated (IP) using antibodies against NF κ B or p53. The resulting IPs were resolved by SDS-PAGE and probed using antibodies specific against acetylated-lysine.

Results: *In vivo*: No mortality was observed in sham animals 44-Hrs post surgery ($n=5$). 70% of animals undergoing HSR died within 4-Hrs of resuscitation and only one animal survived to protocol end; 44-Hrs post-HSR ($n=10$, $p < 0.05$). Liver enzymes (ALT/AST) significantly declined in HSR animals compared to pre-hemorrhage (ALT: 534 ± 122.2 IU/L; AST: 940.4 ± 205.0 IU/L). Scoring of hepatic tissue demonstrated significantly lower Sirt-1 expression in HSR compared to Sham (1.67 ± 0.13 vs. 2.2 ± 0.15). *In vitro*: Analysis of NF κ B and p53 acetylation demonstrated 1.4-fold increase in acetylated NF κ B in HYP hepatocytes compared to CTRL, 6-Hrs post-normoxia. Conversely, HYP hepatocytes treated with resveratrol demonstrated a 65% decrease in acetylated NF κ B compared to CTRL hepatocytes 6-Hrs post-normoxia. Analysis of acetylated p53 expression demonstrated a similar pattern whereby a 1.6-fold increase in acetylation was measured in HYP hepatocytes compared to CTRL, and resveratrol decreased p53 acetylation by 73% compared to basal expression.

Conclusions: Our *in vivo* studies demonstrated a marked decrease in Sirt-1 expression following HSR. Parallel analysis of hepatocytes *in vitro* showed increased NF κ B and p53 acetylation under hypoxic conditions. Resveratrol pretreatment blunted acetylation to a level ≈ 4 -fold lower than that measured in CTRL cells. Collectively, these data suggest Sirt-1 may act as an intermediary between early cell responses to hypoxic stress and the transition to apoptosis. Resveratrol, a Sirt-1 agonist, promoted target protein de-acetylation in response to hypoxic injury meaning Sirt-1 agonists are potential agents for therapeutic use in protecting hepatic tissue following HSR.

EXOGENOUS PHOSPHATIDYLCHOLINE SUPPLEMENTATION IMPROVES INTESTINAL BARRIER DEFENSE AGAINST *C. DIFFICILE* TOXIN

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Invited Discussant: Soumitra Eachempati, MD

Introduction: The incidence and severity of *Clostridium difficile* (*C. diff.*) colitis have increased dramatically in the last decade. Disease severity is related to *C. diff.* virulence factors, including toxins A and B, as well as the patient's immune status. In addition to antimicrobial therapy, previously described adjunctive measures include colonic flora replenishment and immune enhancing therapies. The intestinal mucus is an important component of innate barrier function in the intestine. Phosphatidylcholine (PC) is a key constituent of the intestinal mucus barrier and exogenous PC administration has had therapeutic efficacy in patients with ulcerative colitis. We studied the protective function of exogenous PC on *C. diff.* toxin effects on the intestinal barrier *in vitro*.

Methods: Mucus producing (HT29-MTX strain) and non-mucus producing (HT29 strain) intestinal epithelial monolayers were co cultured with PC and *C. diff.* toxin A added to the apical media. Basal chamber culture supernatants were subsequently obtained and TNF and IL-6 quantitated by ELISA. In other experiments HT29 toxin A uptake, intestinal monolayer permeability, necrosis and actin microfilament disruption were determined.

Results: (mean \pm SD, N = 4 for each group)

	TNF (pg/ml)	IL-6 (pg/ml)	Toxin A(ng/ml)	Perm. (nmol/cm ² /hr)	Necrosis (MFI)
HT29 control	6.7 \pm 1.1	2.5 \pm 0.7	-----	0.34 \pm 0.012	3.8 \pm 0.2
HT29+ <i>C. diff.</i>	39.8 \pm 2.5*	25.3 \pm 1.7*	98.3 \pm 7.9	0.76 \pm 0.021*	17.9 \pm 0.7*
HT29-MTX+ <i>C. diff.</i>	23.3 \pm 1.5*#	11.7 \pm 1.1*#	32.8 \pm 4.0#	0.50 \pm 0.017*#	9.9 \pm 0.5*#
HT29+PC+ <i>C. diff.</i>	9.7 \pm 2.1#	7.6 \pm 1.5*#	25.2 \pm 1.9#	0.38 \pm 0.021#	8.9 \pm 0.3*#
HT29-MTX+PC+ <i>C. diff.</i>	7.5 \pm 2.1#	6.8 \pm 0.9*#	20.4 \pm 1.1# $\$$	0.26 \pm 0.01# $\$$	6.7 \pm 0.3*# $\$$

*p<0.001 vs. HT29 control, #p<0.001 vs. HT29+*C. diff.*, \$p<0.001 vs. HT29+PC+*C. diff.*

Integrity of HT29 cell cytoskeleton was demonstrated by both the mucus layer of the HT29-MTX strain and by exogenous PC administration by phalloidin staining of actin microfilaments.

Conclusion: PC supplementation was effective in improving barrier defense against *C. diff.* toxin A challenge. PC administration may be a useful therapeutic adjunct in severe cases of *C. diff.* colitis or in patients who do not improve with conventional treatment.

CHILDREN ARE SAFER IN STATES WITH STRICT FIREARM LAWS: A NATIONAL INPATIENT SAMPLE STUDY.

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Invited Discussant: Michael Nance, MD

Introduction: Firearm control laws vary across the United States and remain state specific. The purpose of this study was to determine the relationship between variation in firearm control laws and the risk of firearm-related injuries in pediatric population. We hypothesized that strict firearm control laws impact the incidence of pediatric firearm injury.

Methods: All patients with trauma E codes and age < 18 y.o. were identified from the 2009 Nationwide Inpatient Sample. Individual States' firearm control laws were evaluated and scored based on background checks on firearm sales, permit requirements, assault weapon and large capacity magazine ban, mandatory child safety lock requirements, and regulations regarding firearms in college and work places. States were then dichotomized into Strict firearm laws [SFL] or Non-strict firearm laws [Non-SFL] state based on median total score. Primary outcome measure was incidence of firearm injury. Data was compared between two groups using simple linear regression analysis.

Results: 60,224 pediatric patients with trauma related injuries across 44 states were included. 33 states were categorized as Non-SFL and 11 as SFL. 286 (0.5%) cases had firearm injuries of which 31 were self-inflicted. Mean firearm injury rates per 1000 trauma patients were compared between 2 groups (SFL: 2.2 ± 1.6 , Non-SFL: 5.9 ± 5.6 ; $P=0.001$). Being in a Non-SFL state increased the mean firearm injury rate by 3.75 (Beta coefficient: 3.75, 95% CI: 0.25- 7.25; $P=0.036$)

Conclusion: Children living in States with SFL are safer. Efforts to decrease pediatric firearm injuries by improving and standardizing national firearm control laws are warranted.

TRAUMATIC BRAIN INJURY AND BETA-BLOCKERS: NOT ALL DRUGS ARE CREATED EQUAL

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Invited Discussant: Eric Ley, MD

Introduction: Catecholamine surge following traumatic brain injury (TBI) contributes to increased morbidity and mortality. While multiple studies have shown a protective effect of *beta*-adrenergic blockade in TBI, no studies have focused on the most effective drug. We hypothesize that propranolol (PRO) is the best *beta*-blocker (BB) due to its lipophilic properties allowing it to cross the blood brain barrier with central and peripheral *beta*-adrenergic blockade.

Methods: The trauma registry at an urban level-one trauma center was queried for TBI from 1/1/08 to 12/31/11. Patients who received > 1 dose BB were identified after excluding deaths within 48 hours and head abbreviated injury score (Head AIS) < 3 and >5. PRO was then compared to other BB. Multivariable logistic regression analysis was used to adjust for age, admission heart rate, base deficit (BD), transfusions, admission Glasgow Coma Score (ADM GCS), and injury severity score (ISS) to determine whether receiving PRO was protective in patients sustaining TBI.

Results: 1825 patients were admitted with TBI during the study period. 619 (34%) received BB and 79 received PRO. PRO patients were younger (31 vs. 53 yrs, $p<0.001$), but had more severe injury (ISS 33 vs. 28, $p<0.001$), more severe TBI (Head AIS 5 vs. 4, $p<0.001$; ADM GCS 6 vs. 10, $p<0.001$), and higher level of shock on presentation (BD 4.8 vs. 3.2 mmol/L, $p=0.013$; transfusions 3 vs. 2 units, $p=0.05$). Despite being more injured, mortality was lower in the PRO group (3% vs. 14%, $p=0.002$). Stepwise backward multivariable logistic regression analysis identified PRO as protective in TBI (OR 0.203, CI 0.047-0.881), reducing mortality by 80% (independent predictors are listed in table).

	Adjusted OR	CI	<i>p</i>
Propranolol	0.203	0.047-0.881	0.03
Age	1.030	1.016-1.045	<0.001
ADM GCS	0.891	0.846-0.937	<0.001

Conclusions: PRO was associated with significant reduction in mortality in patients with moderate to severe head injury. This inexpensive drug and simple intervention may have profound effects in patients with severe, but salvageable TBI. Further prospective study is warranted.

**THE ROLE OF THYROXINE INFUSION IN PATIENTS
WITH NONSURVIVABLE BRAIN INJURY FOR HEMODYNAMIC
STABILIZATION PRIOR TO THE DECLARATION OF BRAIN DEATH**

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Invited Discussant: Darren Malinoski, MD

Introduction: Thyroxine (T4) infusions are commonly used to maintain organ perfusion in brain dead donors and are associated with improved organ procurement. However, benefits in patients with nonsurvivable brain injury prior to the declaration of brain death have not been well-established. These patients are prone to hemodynamic instability, which may delay completion of clinical brain death exams and even prompt code team activations, thus consuming hospital resources. Such instability may be taxing to family members attempting to make decisions during a difficult time and, importantly, compromise the perfusion of organs that may subsequently be considered for donation. We hypothesized that T4 in patients with nonsurvivable brain injury, prior to brain death declaration, may facilitate the diagnosis of brain death and optimize the potential for organ donation by fostering hemodynamic stabilization.

Methods: This was a retrospective review at an urban, Level-I trauma center over a 5 yr period (9/1/07 – 8/31/12). We included trauma patients with head and neck Abbreviated Injury Score (HNAIS) ≥ 3 who expired 48 hrs to 3 weeks from admission and required a vasopressor or inotrope at any point prior to the declaration of brain or cardiac death (whichever preceded). We excluded patients with evidence of sepsis or hemorrhage outside the first 48 hrs. Primary endpoint was declaration of brain death. Potential risk factors (RF) analyzed included T4 infusion, steroids, age, injury severity score (ISS), Glasgow Coma Scale (GCS) at time of presentation, evidence of shock at time of presentation (including systolic blood pressure, lactate at arrival, and transfusion in trauma bay), neurosurgical interventions and extent of resuscitation (including lactate within 2 hrs of death and net fluid balance at time of death). T4 was administered at the discretion of the treating clinician.

Results: 135 pts were included. Mean age was 46.1 ± 22.1 yrs. 30(22.2%) suffered penetrating mechanism. 100 (74%) were declared brain dead. Mean ISS was 31.7 ± 10.8 ; 127 pts (94%) had HNAIS ≥ 5 . Mean GCS at presentation was 5.2 ± 3.9 . 96 pts (71.9%) required 2 or more pressors or inotropes simultaneously, and 23 experienced ≥ 1 code event. 88 pts (65.2%) received T4.

On binary logistic regression, T4 was the only independent predictor of brain death declaration (O.R. 4.13, $p=0.012$), and was associated with significantly decreased time to declaration or cardiac death (5.56 vs. 2.74 days, $p=0.012$). Significantly fewer T4 pts experienced a fatal code event (4.5% vs. 17%, $p=0.015$), and significantly fewer required norepinephrine, phenylephrine or dopamine infusions.

Conclusions: T4 infusions may hemodynamically stabilize patients with nonsurvivable brain injury, thereby allowing definitive and earlier clinical brain death declaration. Such a benefit would conserve hospital resources, provide closure to grieving families, and potentially increase organ donation.

THE EFFECT OF AGE ON GLASGOW COMA SCALE IN PATIENTS WITH TRAUMATIC BRAIN INJURY

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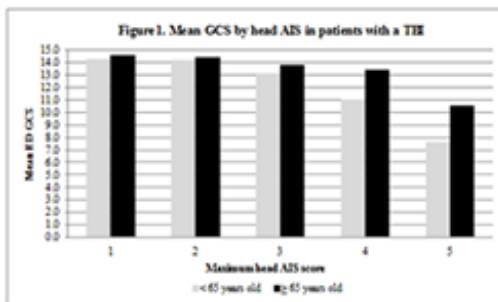
Invited Discussant: Joseph Minei, MD

Introduction: The Glasgow Coma Scale (GCS) is frequently used to define severity of neurologic injury in patients with a traumatic brain injury (TBI). It is unknown whether age affects the predictive ability of GCS for anatomic severity of TBI. Because confusional states are increasingly common with age, we hypothesized that elderly TBI patients would have a worse (lower) GCS compared to younger patients with similar TBI severity.

Methods: We examined all patients with a TBI, defined as head abbreviated injury scale (AIS) ≥ 1 , admitted during 2007–2012 at two level 1 trauma centers. Student's t-tests were used to examine the mean ED GCS at each maximum head AIS score, stratified by age (< 65 vs ≥ 65). GCS components (eye, verbal, motor) and ICD9 diagnosis codes were also examined.

Results: There were 8,629 patients identified with a TBI. Compared to younger adults, elderly TBI patients had more major TBI (AIS ≥ 3 : 39.3% vs 56.0%, $p < 0.001$). At the highest head AIS 5, the majority of elderly patients had a mild neurologic deficit (GCS 13-15, 55.4%), whereas the majority of younger patients had a severe neurologic deficit (GCS 3-8, 61.9%). Further, at every head AIS score, the mean GCS was significantly better for elderly vs. younger TBI patients, particularly with worse anatomic injuries: AIS 4, 13.4 vs 11.0; AIS 5, 10.6 vs 7.6, figure 1. These findings persisted for the subset of patients with an isolated TBI, and patients who suffered a fall cause of injury. There was not a particular GCS component that accounted for the observed differences, while diagnoses of subdural hematoma or subarachnoid hemorrhage showed significant differences in mean GCS, by age.

Conclusions: Age affects the relationship between anatomic severity and GCS in the TBI population. Contrary to our hypothesis, elderly TBI patients have higher GCS scores than younger TBI patients at each level of head AIS. Either elderly patients have a blunted or delayed clinical response to the injury than younger TBI patients, they tolerate equivalent injuries better, or the head AIS overestimates the severity of injury in elderly patients. These findings have implications for TBI outcomes research as well as protocols and research study selection criteria which utilize GCS. The results may also help explain why research in the mild TBI population (GCS 13-15) consistently shows more surgical interventions and worse mortality and functional status for elderly patients than their younger counterparts.



BLOOD COMPONENT TRANSFUSION INCREASES RISK OF DEATH IN CHILDREN WITH TRAUMATIC BRAIN INJURY

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Invited Discussant: David Notrica, MD

Introduction: Blood transfusion has been associated with worse outcomes in adult trauma patients, including those with severe traumatic brain injury (TBI). However, the effects of blood transfusion in injured children have not been evaluated. We hypothesize that blood transfusion is also associated with worse outcomes in children with TBI.

Methods: A retrospective review of the trauma database at a level one pediatric trauma center was performed. All children age 18 years old and under with a diagnosis of TBI between 2002 and 2012 were included. Exclusion criteria include those who underwent craniotomy in order to eliminate possible confounding factors of intraoperative blood loss. A policy of restricted transfusion was not in place during this time. Data collected include age, sex, injury severity score (ISS), GCS on presentation, cause of injury, number and type of transfusions, infectious complications, and outcome. Univariate and multivariate analysis were performed.

Results: A total of 1602 children with TBI who did not undergo craniotomy were identified (average age 5.6 (\pm 5.1) years; 65% male). The most common causes of injury include abusive head trauma (AHT) (N= 378, 23%), fall (N=345, 22%), and motor vehicle crash (N=264, 16%). Mean injury severity score (ISS) was 18.7 (\pm 11.3); mean GCS on presentation was 11.9 (\pm 4.4). A total of 271 (17%) patients received a blood component transfusion; 249 received pack red blood cells (PRBCs), 101 received fresh frozen plasma (FFP), 23 received platelets, and 17 received cryoprecipitate. Data are presented in Table 1. After controlling for age, sex, ISS, and GCS on presentation, patients who received any blood product transfusion had an increased risk of dying, being dependent on caretakers at follow up, and requiring an ICU stay. They also had an increased risk of developing the following infectious complications: positive blood culture, pneumonia, and urinary tract infection (UTI).

Table 1	No Transfusion (N=1331)	Any Transfusion (N = 271)	OR	95% CI	P value
Survival to hospital discharge	1298 (81%)	176 (65%)	4.2	2.4-7.3	<0.0001
Discharge to rehab	126 (8%)	92 (33%)	1.5	1.0-2.3	0.05
Dependence on caretakers	74 (5%)	58 (21%)	4	2.3-6.7	<0.0001
ICU stay	863 (5%)	236 (87%)	3.2	1.9-5.3	<0.0001
Infectious complications:					
Positive blood culture	3 (0%)	9 (3%)	7.7	1.3-44.5	0.02
Pneumonia	18 (1%)	28 (10%)	2.5	1.2-5.4	0.01
UTI	7 (0%)	15 (6%)	7.7	2.3-25.5	<0.001
Sepsis	1 (0%)	4 (1%)	13.4	0.8-228.2	0.07

Conclusion: Pediatric patients sustaining traumatic brain injury who receive a blood product transfusion and do not require operative interventions have worse outcomes compared to patients who do not receive a transfusion. This includes an increased risk of death. These data suggest that a restrictive transfusion policy in injured children with TBI may be beneficial.

WHEN BIRDS CAN'T FLY: AN ANALYSIS OF ADVANCED LIFE SUPPORT GROUND TRANSPORT WHEN HELICOPTER EMERGENCY MEDICAL SERVICE (HEMS) IS UNAVAILABLE

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Invited Discussant: Dennis Ashley, MD

Introduction: HEMS transport of trauma patients is costly and of unproven benefit. Recent retrospective studies are limited by comparison of non-similar groups, failing to control for crew expertise. Prior studies may therefore represent comparisons of highly-trained ALS versus less-trained BLS crews. The purpose of our study was to compare HEMS to GND transport controlling for crew training.

Methods: Our NTRACS database was queried to identify consecutive hospital transfers (1/1/08-11/1/12) to our ACS Level I center. Utilizing an HEMS database, the transfers were divided into two groups, those transported by HEMS, and those for whom HEMS was requested but were transported by ground (GND) due to weather or lack of HEMS availability. HEMS and GND cohorts included only transports by an ALS crew. Cohorts were compared across standard demographic and clinical variables using univariate analysis. Multivariate logistical regression was performed to determine the relationship of these variables to mortality.

Results: On univariate analysis, the HEMS (n=2,190) and GND (n=226) cohorts were well-matched; no significant differences were noted for demographics, mechanism of injury, injury severity (14.6±10.6 vs. 14.0±9.5), RTS (9.5±3.6 vs. 9.6±3.6), length of stay, or complications. Mean time from injury to definitive care was significantly lower for HEMS (203±177 minutes vs. 293±158, $p < 0.001$). Mortality was not different between HEMS and GND (9.0% vs. 8.0% $p = 0.713$).

Multivariate regression analysis identified no relationship between transport mode and mortality. When transport mode was added to the mortality model, the p value was 0.772.

Conclusions: Despite significantly faster transport times, HEMS offers no mortality benefit versus GND when crew expertise is similar, contradicting recent large, retrospective National Trauma Databank studies failing to control for crew training. Given the entrenched status of HEMS, our methodology, focusing on patients that a referring provider deemed worthy of HEMS, may represent the best possible approximation of a prospective study. Although HEMS may seem intuitively beneficial for time-dependent injuries, larger studies with a similar methodology are warranted to justify the cost and risk of HEMS, and to identify subsets of patients who may truly benefit.

Mortality Multivariate Logistic Model

	<i>p</i>	Adjusted Odds Ratio	95% C.I.	
			Lower	Upper
Cube of Age	< 0.001	1.00000575	1.000005	1.000007
Square Root of ISS	< 0.001	2.313	1.961	2.728
Revised Trauma Score	0.001	0.817	0.724	0.922
Temperature	< 0.001	0.836	0.76	0.921
Penetrating Injury	0.006	2.005	1.218	3.301
Advanced Airway	0.03	3.075	1.117	8.46
Pneumonia	0.001	0.331	0.172	0.636
Urinary Tract Infection	0.037	0.302	0.098	0.932
Acute Renal Failure	0.009	14.733	1.932	112.323

**A CONCLUDING AFTER ACTION REPORT OF THE SENIOR VISITING
SURGEON PROGRAM WITH THE UNITED STATES MILITARY AT
LANDSTUHL REGIONAL MEDICAL CENTER, GERMANY**

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Invited Discussant: Donald Jenkins, MD

Introduction: The Senior Visiting Surgeons Program was developed to build military-civilian collaboration during the wars in Iraq and Afghanistan. The purpose of this study was to evaluate the program with the hypothesis that key elements of success could be identified as well as factors essential for sustainment and readiness during peacetime.

Methods: A survey designed by members of the AAST Military Liaison Committee was distributed electronically to 192 surgeons who participated in the program at Landstuhl Regional Medical Center, Germany (LRMC) between the years 2005-2012. LRMC has been the US military's level IV hospital for service members injured over the decade of war. The survey included multiple choice and open-ended questions regarding clinical, research and mentoring experiences during the 2-week rotation.

Results: The response rate was 61% with the largest number of respondents being vascular surgeons. Among respondents, 24% had prior military service and 22% rotated through LRMC more than one time (range 1-5 tours). Overall, 76% rated the experience as extremely satisfying. On average, senior visiting surgeons participated in 2-5 operative cases per week a number which varied with operational tempo. The majority of operations were directed at wound and burn care, followed by abdominal and vascular procedures. Over 60% of visiting surgeons felt that their time in the intensive care unit was most valuable and 16% collaborated in research resulting in a number of published manuscripts. The military Clinical Practice Guidelines found to be most translatable to civilian practice included management of complex wounds and prophylaxis for venous thromboembolism. Half of the surgeons maintained contact with military colleagues over the ensuing year. An overwhelming majority (94%) support continuation of the program at US military bases and 86% which would welcome military surgical residents into their civilian training programs.

Conclusions: This report codifies the most prolonged civilian-military wartime surgical collaboration in US history. Visiting civilian surgeons were honored to be allowed to participate in the care of wounded warriors, filled occasional gaps in surgical care and provided important mentorship. Continuation of key elements of this program including shared research platforms, cross-training between military and civilian surgical programs, and the evolution of practice management guidelines for the critically injured will assure the sustainability of this successful program during inter-war periods

**CLEARED FOR TAKEOFF: THE EFFECTS OF HYPOBARIC CONDITIONS
ON TRAUMATIC PNEUMOTHORACES**

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Invited Discussant: Erik Barquist, MD

Introduction: Current medical guidelines suggest that traumatic pneumothorax (PTX) is an absolute contraindication to commercial airline travel and patients should wait at least two weeks after radiographic resolution of their PTX to fly. This recommendation is rather arbitrary, and not based on prospective, physiologic study. We hypothesized that despite having a radiographic increase in pneumothorax size while at increased altitude, patients would not exhibit any adverse physiologic changes nor report any subjective symptoms of cardiorespiratory compromise.

Methods: Prospective, observational study of 10 patients with a traumatic PTX that had been treated, either by chest tube (CT) or high flow oxygen therapy. CT must have been removed within 24 hours of entering the study. Subjects were acutely exposed to 2 hours of hypobaria (554mm Hg) in a chamber simulating an altitude of 8400 feet, similar to a pressurized commercial airline cabin during flight. A trauma service clinician with a CT kit and a radiologic technologist were in the chamber with the subject. Vital signs including oxygen saturation and subjective symptoms were recorded every 10 minutes during the “flight”. After 2 hours, while still at simulated altitude, a portable CXR was obtained. This CXR was compared to a pre-“flight” CXR, and the difference in PTX size was measured.

Results: 10 subjects successfully completed the 2 hour flight. 9 (90%) were male. Mean age was 56±5 years. Mean ISS was 10.5±1.4. 6 (60%) had a CT to treat PTX. In those with a CT, it had been removed a mean of 17 (range 4-21) hours prior to beginning the study. No subject complained of any cardiorespiratory symptoms while at simulated altitude. Average radiographic increase in PTX size at altitude was 6.3mm (26%) from pre-flight CXR. No subject developed a tension PTX. No subject required any procedural intervention during the flight, or immediately after.

Conclusion: : Patients with traumatic PTX have a small increase in the size of PTX when subjected to simulated altitude. This appears to be clinically well-tolerated, however. Current prohibitions regarding air travel following traumatic PTX should be reconsidered and further studied.

COMPLETE ULTRASONOGRAPHY OF TRAUMA (CUST) IN SELECTED BLUNT TRAUMA PATIENT IS AN EQUIVELANT SCREENING EXAM TO COMPUER TOMOGRAPHY AND IS ASSOCIATED WITH REDUCED RADIATION EXPOSURE AND INCREASED COST SAVINGS

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Invited Discussant: Jason Sperry, MD, MPH

Introduction: Many major trauma victims undergo routine screening CT scan examinations to rule out blunt abdominal trauma (BAT). Increasing costs and radiation exposure have heightened concerns for this practice. We sought to demonstrate that in a select group of BAT patients, our protocol for Complete Ultrasonography of Trauma (CUST) is equivalent to routine CT imaging but associated with significantly decreased radiation exposure and cost.

Methods: A retrospective analysis of patients screened for BAT from 2000 – 2011 in a level-1 trauma center was performed. CUST was performed by experienced sonographers using our previously published protocol. Interpretations were performed by attending radiologists. CUST was available from 0800 – 2300 daily. Between 2300 and 0800, routine abdominal CT was used (CT). Decision to perform CT or CUST between 0800 and 2300 hours was at the discretion of the attending trauma surgeon based on clinical exam and associated injuries. False negatives (FN) were described as either negative CUST or CT imaging which later required a laparotomy, (FN-CUST or FN-CT, respectively). Demographics and outcome data were compared. Mean Medicare rates were used to compare costs. Prior published data for radiation exposure per abdominal CT scan examination was used for estimation of radiation exposure savings.

Results: There were 19,128 patients screened for BAT. 12,565 (61%) patients underwent initial CUST and 8,057 underwent routine initial CT. 385 of the 493 positive CUST patients and 1,119 of the 12,070 negative CUST patients underwent subsequent CT. A total of 11068 patients (58% of the total BT patients) avoided a CT, yielding an estimated savings of \$5.5 million and 188,156 mSv less in radiation dose exposure. Compared to the CT group, patients undergoing CUST had lower ISS (8.1 vs. 9.6, $p < 0.001$), were older (44.7 vs. 35.2, $p < 0.001$), had lower Abdominal AIS (2.0% vs. 3.6%, $p < 0.001$) less hollow viscus injury (0.4% vs. 0.8%, $p = 0.002$), and less traumatic brain injury (61.4% vs. 69.3%, $p < 0.001$). Mortality was higher in the CUST group (1.8% vs. 1.2%, $p = 0.02$) but it is insignificant when adjusted for age > 65 (1.1% vs. 0.9%, $p = 0.02$) or head injury (0.6% and 0.3%, $p = 0.4$). FN-CUST and FN-CT were both 1% of the images performed. ICU length of stay (20.8 vs. 20.6, $p = \text{NS}$), ventilator days (15.6 vs. 14.9, $p = \text{NS}$), hollow viscus injury rates (8.8% vs. 5.6%, $p = \text{NS}$) and mortality (6.6% vs. 5.6%, $p = \text{NS}$) were similar for FN-CUST and FN-CT, respectively. Sensitivity, specificity, positive predictive value and negative predictive value of CUST were 46%, 97%, 24% and 99%, respectively.

Conclusion: A surgeon-directed CUST protocol is equivalent to routine CT for blunt abdominal injury screening, but leads to 42% less radiation exposure and over \$500,000 savings per year.

PAN CT VERSUS SELECTIVE CT IN BLUNT TRAUMA: A COST-UTILITY ANALYSIS

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Invited Discussant: Samir Fakhry, MD

Introduction: Pan CT (PCT) of the head, c-spine, chest, abdomen, and pelvis is a beneficial approach to the initial evaluation of severely injured blunt trauma patients. PCT is also widely used in patients with lower injury severity, however the cost to benefit ratio is unknown. The advantage of rapidly identifying nearly all injuries must be weighed against the risk of radiation-induced cancer. Our goal is to determine the cost utility of PCT in blunt trauma patients with low injury severity. We hypothesize that PCT is cost effective.

Methods: This is a Markov model based, cost-utility analysis of a hypothetical cohort of hemodynamically stable, 30 year-old males after motor vehicle crash. The model compared PCT to selective CT scans (SCT); indication for CT was mechanism of injury. The analysis was over a one year time frame with an analytical horizon including the lifespan of the patients. The probability of possible outcomes, utilities of health states, and health care costs including radiation-induced cancer (Table 1) were derived from reviews of the medical literature and public data. Costs were measured in U.S. 2010 dollars and incremental effectiveness was measured in quality adjusted life-years (QALYs), both calculated at a 3% annual discounted rate. Multi-way sensitivity analyses were performed on all variables.

Results: The total cost for blunt trauma patients undergoing PCT is \$15,668 vs. \$17,212 for SCT. There is no significant difference in QALYs between the two groups (26.42 vs. 26.40). There is a cost savings of \$59 per QALY in patients receiving PCT vs. SCT (\$593/QALY vs. \$652/QALY). Sensitivity analyses never reached threshold with any variable, but approached threshold when the cost of SCT and the cost of observation for patients with a negative SCT were minimized.

Table 1: Costs and Utilities (US 2010 dollars)

Parameters	Total Cost	First Year Utility
ED Discharge After Negative PCT	\$13,293	0.99
Observation after Negative SCT	\$14,507	0.95
Routine Trauma Admission	\$16,304	0.82
Non-Critical Occult Injury	\$28,530	0.78
Critical Occult Injury	\$44,929	0.75
Radiation-Induced Cancer	\$337,847	0.72

Conclusions: PCT enables surgeons to identify, and rule out, injuries promptly - thereby reducing the need for inpatient observation. Additionally, the risk of radiation-induced cancer is low following a single PCT. This cost-utility analysis finds PCT based on mechanism, with early discharge of the uninjured, is an effective utilization of limited health care resources.

OUTCOMES OF ABDOMINAL TRAUMA PATIENTS WITH HEMORRHAGIC SHOCK REQUIRING AN EMERGENCY LAPAROTOMY: EFFICACY OF INTRA-AORTIC BALLOON OCCLUSION

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Invited Discussant: Joseph Rappold, MD

Introduction: The aims of this study were to investigate outcomes of abdominal trauma patients with hemorrhagic shock requiring an emergency laparotomy, and to clarify the beneficial effects of intra-aortic balloon occlusion (IABO) in intra-abdominal hemorrhage for patients with critically uncontrollable hemorrhagic shock (CUHS).

Methods: We reviewed 44 patients with hemorrhagic shock who underwent an emergency laparotomy for intra-abdominal hemorrhage between January 2007 and December 2012. Of these patients, we examined the data on 19 patients who underwent IABO using the percutaneous occlusion balloon catheter purchased from SENKO MEDICAL INSTRUMENT Mfg. Co., Ltd. Japan during initial resuscitation to control massive intra-abdominal bleeding leading to CUHS.

Results: The average Injury Severity Score (ISS) and Probability of survival (Ps) of the 44 patients were 27.6 ± 15.4 and 0.735 ± 0.304 , and the overall survival rate was 77.3%. Two of the patients had a possibly preventable trauma-related death. Thirty-one of these patients (70.5%) had already been in vital shock when they arrived at the emergency room, while 13 of them (29.5%) went into vital shock during the early medical examination and treatment. The average time from the onset of vital shock to laparotomy was 88 ± 39 min. The difference in the lactate level (5.1 ± 4.1 mmol/L) and body temperature (36.1 ± 1.2 C) between the two groups (survival or expired) was statistically significant ($P < 0.05$). Furthermore, 23 patients had CUHS, and the survival rate of those patients was 60.9%, which was significantly poorer than that (95.2%) of 21 patients without CUHS ($P = 0.0102$). IABO was attempted in 19 of 23 patients (82.6%) with CUHS, and in all patients, these balloons were successfully placed in 8.1 ± 3.3 minutes in thoracic aorta, and a significant increase in systolic blood pressure was observed immediately after IABO. We could repeat the inflation/deflation of balloons or perform 1/3~2/3 inflation to shorten the total occlusion time, and therefore, we could perform the operation while ensuring stable conditions. Nevertheless, seven of the 19 patients (36.8%) died; five due to progressive intra-abdominal hemorrhagic shock after the operation and two because of brain edema or heart injury.

Conclusion: The IABO procedure can be life-saving during the management of patients with CUHS arising from intra-abdominal hemorrhage, permitting transport to surgery. However, the decision to perform such treatment (IABO and laparotomy) must be made as quickly as possible after trauma to reduce the duration of occlusion.

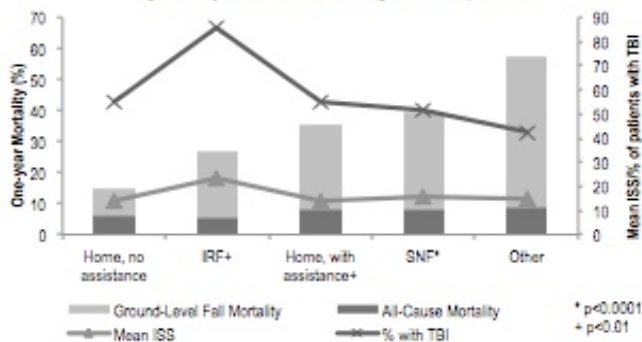
LONG-TERM OUTCOMES OF GROUND-LEVEL FALLS IN THE ELDERLY

Lisa McIntyre MD, Christopher Mack M.S., Patricia Ayoung-Chee MD, MPH, Beth Ebel MD, Wayne McCormick MD, Ronald V. Maier* MD, Harborview Medical Center

Invited Discussant: Clay Cothren Burlew, MD

INTRODUCTION: For older adults, even ground-level falls (GLF) can result in multiple injuries and are associated with significant morbidity and mortality. Previous studies have focused on in-hospital outcomes and patients with isolated injuries. Our study examines outcomes following discharge for older adults who were hospitalized following a GLF. **METHODS:** Retrospective cohort study of patients > 65 years old admitted to a Level I trauma center, from 2005 to 2008, after a GLF. Hospital trauma registry data were linked to state hospital discharge data and the death certificate registry. Skilled nursing facilities (SNF) were contacted to verify ultimate patient placement, with follow-up through December 2010. Kaplan-Maier and Cox proportional hazards models were used to analyze post-discharge mortality. **RESULTS:** There were 1,352 consecutive admissions; 48% had an ISS > 15 and 12% died during admission. Of the patients who survived hospitalization, 51% were discharged to SNF, 33% to home without assist, 6% to home with assist and 5% to inpatient rehabilitation facilities (IRF). Within one year of injury, 31% of patients were readmitted. The one-year mortality for this cohort of was 33%, significantly greater than age- and sex-matched all-cause mortality (Figure 1). After adjusting for confounders, patients

Figure 1. Ground-Level Fall vs All-Cause One-Year Mortality, age- and gender-adjusted, based on Washington State Population



discharged to SNF had a three-fold greater risk of one-year mortality (HR 2.63; CI 2.01-3.43), compared to patients discharged home without assist. Patients discharged home with assist also had a significantly higher risk of mortality (HR 1.75; CI 1.14-2.67), but patients discharged to IRF did not (HR 1.02; CI 0.53-1.99). Of the patients discharged to SNF, 48% died by the end of the follow-up period and 61% of these died while residing at a SNF.

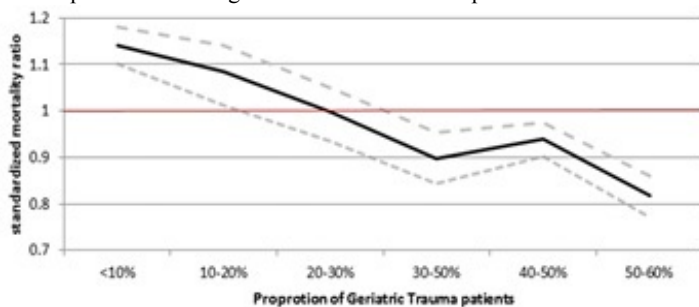
CONCLUSION: Ground-level falls in the elderly result in severe injury, readmissions and increased mortality, both in-hospital and post-discharge. One-third of patients were discharged home to independent living, despite having a moderate injury severity and high proportion of TBI. Although less severely injured than those discharged to IRF, patients discharged to SNF or home with assist were more likely to die during the year following injury. Future efforts should examine modification of criteria for post-discharge options in improving outcomes and their cost effectiveness.

COSTS AND OUTCOMES OF TRAUMA CARE AT CENTERS TREATING A HIGHER PROPORTION OF OLDER PATIENTS: THE CASE FOR GERIATRIC TRAUMA CENTERS

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Invited Discussant: Marc de Moya, MD

Introduction: The burden of injury among older patients continues to grow. Trauma management and outcomes are known to differ between old and young patients. Our objective is to determine if older trauma patients have better outcomes at centers with higher volumes of older trauma patients and whether cost of trauma care for the elderly varies by volume of older patients treated at a center. **Methods:** We analyzed level 1 and 2 trauma centers contributing to the 2007-2010 National Trauma Databank (NTDB) with at least 500 trauma admissions per year. Patients were grouped as older (O, ≥ 65 yrs) and younger adults (Y, 16-64 yrs). Multivariate logistic regression was performed to determine differences in demographics/ injury severity, and coarsened exact matching was used to determine differences in mortality between older (O) and younger (Y) adults. Trauma centers were then categorized by the proportion of older trauma patients seen and hierarchical modeling techniques were applied to determine differences in outcome by proportion of O patients. Risk adjusted Observed to Expected mortality ratios were calculated and plotted against proportion of O trauma patients. Using the Nationwide Inpatient Sample (NIS) generalized linear modeling with a log link and gamma distribution was used to determine adjusted cost differences for O patients across trauma centers by proportion of O trauma patients seen. **Results:** Older patients accounted for 24% of trauma visits. Numerous independent differences between O and Y trauma were identified. Matched analysis revealed that O trauma patients were 6.2 (5.79-6.57) times more likely to die than similarly injured Y patients. Older patients presenting at centers that treat a high proportion of elder trauma were 24% less likely to die than those presenting at lower proportion centers (OR= 0.76, 95% CI: 0.56-0.97) (figure 1). Additionally the average cost of care for O trauma patients was lower by 11% or \$2,650 (\$2,630-2,672) per patient at centers that saw a high proportion of O trauma when compared with low proportion centers (OR= 0.89, 0.886- 0.895). **Conclusions:** Geriatric trauma patients treated at centers with a higher proportion of older patients have improved outcomes and incur lower costs. This evidence supports the notion of older trauma patients receiving care at trauma centers specialized in care for older patients.



Hospital Readmission to an Academic Level I Trauma Center Within 30 Days of Discharge

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Invited Discussant: John Fildes, MD

Introduction: Readmission to the hospital within 30 days of discharge is a costly event. Recent changes for reimbursement from Centers for Medicare and Medicaid Services (CMS) makes avoiding readmission within 30 days of discharge a top priority for all institutions. Studies published in the literature have shown readmission rates for medical and surgical patients may occur as high as 20 percent. However, there are only limited reports addressing the trauma population specifically. Our goal was to examine the readmission rates, reasons, and processes at an academic Level I trauma center.

Methods: Readmissions within 30 days of hospital discharge after trauma were tracked by nurse registrars and entered into the Trauma Registry. Dates of admission, discharge, diagnosis, procedure codes, and admitting service were reported and linked to the trauma registry record for the original injury. This report examines readmissions occurring over a four year period (2009 - 2012), comprising 3622 patients. Only unscheduled readmissions (USR) are reported in this study. For this study, patients under 18 years of age were excluded. Pre-existing conditions and hospital complications are those described and collected in the National Trauma Data Standard (NTDS).

Results: The readmission rate within 30 days in our patient population was 6.57% (238 of 3622). Patients with a USR were older (61.5 vs. 52.9, $p<0.001$), had a longer initial admission (18.4 days vs. 9.9, $p<0.001$) and had initially sustained more severe injuries (ISS 13.3 vs. 11.3, $p=0.001$) on the first admission. Initial admissions which required a major neurologic, thoracic, or abdominal operation were associated with a higher USR (11.3% vs. 5.8%, $p=0.02$). However there was no significant difference for those with an orthopedic operation alone (38.9% vs. 42%, $p=0.337$). Patients with pre-existing anticoagulation/antiplatelet therapy, diabetes, or hypertension had an increased risk of a USR. Logistic regression demonstrated that patient age, length of stay, discharge to a skilled or subacute nursing home, and the presence of any pre-existing condition were associated with USR. Notably, a complication during the first hospitalization, a major operation, or a high ISS was not found to be independent risk factors for USR. The most frequent indications for USR were infection (31%), unrelated medical condition (19%), and pain (10.5%).

Conclusion: Unscheduled readmission rates following hospitalization for traumatic injury at a level I Trauma Center are lower than the rates reported for medical or surgical patients. The number of patients readmitted for unrelated medical issues and the increasing age of the trauma patient has concerning financial implications particularly in light of the CMS reimbursement changes. Trauma centers should and need to identify patients at risk for USR, and identify strategies to reduce the risk.

HOW ARE YOU REALLY FEELING? A PROSPECTIVE EVALUATION OF COGNITIVE FUNCTION FOLLOWING TRAUMA

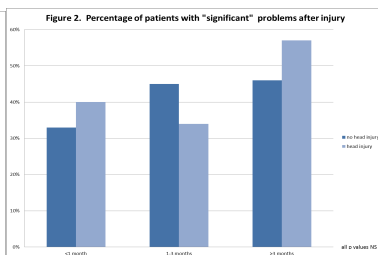
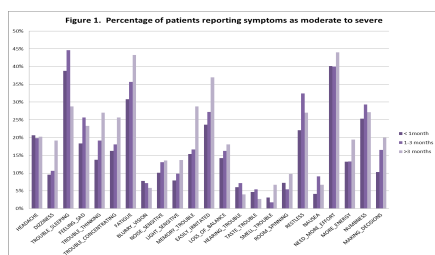
Deborah M. Stein* MD,MPH, Erin C. Hall MD, Eric Lund MS, Diane Brown RN, Karen R. Murdock DScPT, Lisa Gettings MS, Thomas M. Scalea* MD, R Adams Cowley Shock Trauma Center

Invited Discussant: Kristan Staudenmeyer, MD

Introduction: It is well-known that mild traumatic brain injury (TBI) is highly associated with cognitive difficulties that can persist for weeks to months following injury. However, these symptoms are non-specific and are also referable to overall poor health and post-traumatic stress disorder. We sought to evaluate the incidence of these symptoms in patients following trauma.

Methods: A prospective analysis of a convenience sample of patients who were seen in the outpatient trauma clinic over a 20-month period and completed self-administered Rivermead Post Concussion Symptoms Questionnaire (RPQ) was conducted. The time of the completed RPQ was stratified into Early (<1 month following injury), Mid (1-3 months) and Late (>3 months) and the patient was matched with their Trauma Registry data. Patients reporting symptoms as moderate to severe were considered positive, and “significant” difficulty with cognition was defined by ≥ 2 symptoms reported as severe or ≥ 4 symptoms reported as moderate. Head injury was defined as Head AIS >0, including the diagnosis of concussion.

Results: 586 completed questionnaires were matched to Trauma Registry admissions (393 Early, 118 Mid, 75 Late). Patient characteristics included: 73% males, mean age 37 ± 16 years, median ISS 12 (4-21), median length of stay 2.8 days (0.4-7.8), 28% head injury diagnosis. The incidence of symptoms is shown in figure 1. 35% at <1 month, 41% at 1-3 months, and 48% of patients at >3 months following injury were having significant difficulty with cognition. Only 17%, 14%, and 19% had returned to work or school at the 3 follow up time frames and only 5% and 3%, 15% and 9%, and 23% and 5% were receiving psychiatric or cognitive rehabilitation services, respectively. There was no significant difference in symptomatology in patients who carried a head injury diagnosis and those that did not (figure 2).



Conclusion: Cognitive problems occur frequently following injury even in the absence of a head injury diagnosis. Either mild TBI is grossly underdiagnosed or these symptoms are not specific to post-concussive states and simply are the cognitive sequelae of traumatic injury. The reporting of moderate to severe symptoms suggest a need to better understand the affects of trauma on cognitive function and strongly suggests that services for these patients are badly needed to maximize cognitive function and return to pre-injury quality of life.

MID-TERM, AMPUTATION FREE SURVIVAL AND PATIENT BASED OUTCOMES FOLLOWING WARTIME VASCULAR INJURY

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Invited Discussant: Matthew J. Wall, Jr., MD

Background: Extremity vascular injury is a leading cause of morbidity and amputation in combat. Throughout the decade of war clinical studies have focused on early management strategies and short-term statistical limb salvage. To date mid- and long term quality of life and functional limb salvage have not been quantified in US service personnel. The objective of this study is to characterize patient based outcomes following wartime extremity vascular injury including mid-term freedom from amputation and functional recovery using standardized survey questionnaires.

Methods: The Global War on Terrorism Vascular Initiative Oracle® database was queried for US troops having undergone attempted limb salvage following extremity vascular injury in Afghanistan or Iraq (2002-2012). Demographics, injury characteristics and management strategies were recorded. Patients were contacted, consented, and surveyed using the standardized Short Form 36 (SF36) and Short Musculoskeletal Function Assessment (SMFA). The SF36 is comprised of mental (MCS) and physical (PCS) composite scores with a recognized national norm of 50. The SMFA is comprised of dysfunction (DI) and bother (BI) indices with validated extremity injury norms 27±17 and 31±21 respectively.

Results: A total of 227 respondents completed both SF36 and SMFA surveys (98% male; age 24±3 years). The majority of respondents had lower (n=138; 61%) compared to upper (n=95; 42%) extremity vascular injury. Mean injury severity (ISS) and mangled extremity severity (MESS) scores were 14.5±8 and 5.7±1 respectively. Injuries were isolated artery (n=152; 67%), vein (n=22; 10%) or combined artery and vein (n=53; 23%). Fifty-four percent (n=124) of respondents had associated fracture while 57% (n=130) and 90% (n=204) had nerve and soft tissue injuries respectively. Thirty-six (16%) patients had secondary amputation at a mean of 7 months after injury and initial vascular repair. Forty-two percent (n=96) of respondents were active duty status at a mean follow-up of 51±31 months following injury and amputation free survival at this same time was 84%. For the entire cohort, mean SF36 MCS and PCS were 47±13 and 43±9 respectively, and mean SMFA DI and BI were 25±15 and 26±11 respectively. There was no difference between SF36 component scores between those with limb salvage and those with secondary amputation (MCS: 46±9.3 vs. 49±8.9; p=0.07 respectively and PCS: 43±9.3 vs. 40±8.9; p=0.07 respectively). Active duty status at the time of survey was independently associated with favorable SF36 MCS (p=0.0001) and SMFA DI (p=0.05).

Conclusions: This study characterizes patient based outcomes following wartime vascular injury. Findings demonstrate a favorable mid-term limb salvage rate and underscore the resiliency of a military population including the benefit of active duty status during recovery. A physical and emotional burden exists among patients with limb salvage which limits their recovery. Further study of this burden is necessary to improve long-term function after wartime vascular injury.