

Session I

Paper 1 7:50

HEPATIC RESECTION IN THE MANAGEMENT OF COMPLEX INJURY TO THE LIVER

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Presenter: Patricio Polanco, M.D.

Invited Discussant: H. Leon Pachter, M.D.

Objectives: The general success of nonoperative management of blunt hepatic injury and the high reported mortality of hepatic resection for trauma has promulgated the approach that resection has no role in the management of hepatic trauma. Hypothesis: with appropriate expertise, including the use of delayed hepatic resection, liver resection can safely control hemorrhage and minimize septic complications. **Methods:** 216 adult patients with AAST grade III-V hepatic injuries, admitted from 1986-2001 to a Level I trauma center, were reviewed. 56 of 216 patients (26%) underwent liver resection; these patients are the basis of this report. **Results:** Patient age was 32.7 ± 13.6 years; Injury Severity Score averaged 34 ± 11 ; liver injury grades were grade III(16%), grade IV (57%) and grade V(27%); 62.5% blunt and 37.5% penetrating. Indication for liver resection was uncontrolled bleeding or extensive tissue disruption necrosis in 86% of patients. 28.5% (16/56) had major associated vascular injury (IVC, portal vein, or hepatic veins). 62.5% of patients had other intra-abdominal injuries. Liver resection included segmentectomy (21); left lobectomy (3); right lobectomy (8); nonanatomic resection (23); and liver transplantation (1). Liver resection was performed at the initial operation in 84% of patients; as delayed anatomic resection in 16% of patients. Morbidity related to liver resection was 25% (bile leak or abscess). Overall mortality was 17.8%; mortality related to liver injury was 10.7%. **Conclusions:** High grade hepatic injuries often have associated major vascular injury. Hepatic resection for trauma provides definitive control of bleeding and excision of nonviable tissue. Liver resection in this group of severely injured patients, often applied in delayed fashion, yielded low hepatic related mortality.

Session I

Paper 2 8:10

SPLenic ARTERY EMBOLIZATION: HAVE WE GONE TOO FAR?

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Jeffery A. Jednacz, MD: Rhode Island Hospital, Brown Medical School, Dept of Diagnostic Imaging

Robert Lambiase, MD: Rhode Island Hospital, Brown Medical School, Dept of Diagnostic Imaging

Walter L. Biffl, MD*: Rhode Island Hospital, Brown Medical School, Dept of Surgery

Presenter: Hadley E. Smith, M.D.

Invited Discussant: Kimberly A. Davis, M.D.

Splenic artery angioembolization (EMBO) has been promoted to increase the success rate of non-operative management of splenic injuries. Our institutional clinical pathway calls for EMBO in the setting of ongoing splenic bleeding or contrast blush on CT scan. We perceived a higher rate of failure than that reported in the literature. The purpose of this study was to review our experience with splenic EMBO to identify predictors of failure of nonoperative/EMBO management. **Methods:** The trauma registry and interventional radiology database of a level I trauma center were reviewed for patients with splenic injuries from January 2000-June 2004. Charts and films of patients undergoing EMBO were reviewed. **Results:** 221 patients were admitted with blunt splenic injuries. 165 (75%) were selected for nonoperative management; 41 (25%) of them underwent splenic EMBO. 24 patients (15%) failed nonoperative management. Failures (%) by grade were as follows:

Grade	I		II		III		IV		V		Total
	Total	Failed	Total	Failed	Total	Failed	Total	Failed	Total	Failed	
NonOP	31	1 (3)	67	2 (3)	43	10(23)	19	9 (47)	5	2 (40)	165
NoEMBO	31	1 (3)	54	2 (4)	28	4 (14)	11	6 (55)	0	0	124
EMBO	0	0	13	0	15	6 (40)	8	3 (38)	5	2 (40)	41

57% of patients who experienced transient hypotension, required splenectomy. 0 of 9 patients with low grade injury (I,II) and small or no hemoperitoneum failed EMBO, whereas 11 of 24 (46%) with high grade (III,IV,V) and moderate or large hemoperitoneum failed. EMBO was more likely to fail if extravasation was seen on angiogram, 59% vs 4%. Coils (vs. particles) and main (vs. selective) artery EMBO were more often successful. **Conclusions:** EMBO may have salvaged many spleens, but splenectomy was required in 27% of patients. Patient selection is critical to successful management. Any hypotension in the face of a contrast blush probably warrants laparotomy. The combination of high grade injury and significant hemoperitoneum, or extravasation on angiogram, predict a high risk of failure and thus warrant a low threshold for splenectomy if bleeding persists. Technical EMBO considerations may impact success, but this requires further investigation.

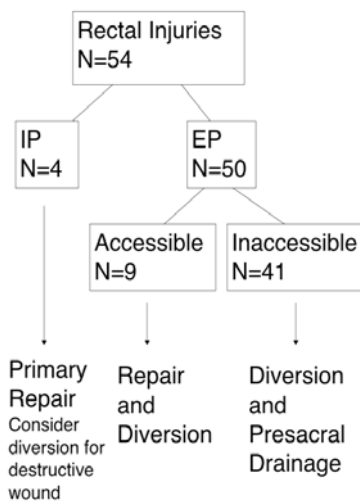
PENETRATING RECTAL TRAUMA: MANAGEMENT BY ANATOMIC DISTINCTION IMPROVES OUTCOME

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 Timothy C. Fabian M.D.*, University of Tennessee Health Science Center
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Presenter: Jordan A. Weinberg, M.D.

Invited Discussant: David H. Livingston, M.D.

Background: Controversy persists regarding the optimal management of penetrating rectal injuries, specifically with respect to the routine application of diversion and presacral drainage. Our previous experience suggested that management decisions based on precise anatomic characterization of injury relative to retroperitoneal involvement might improve outcome (*Am Surg*, 1998). A management algorithm was developed and implemented [Figure]. Patients managed by the algorithm (ALG) were compared to the previous study (PS, n=58) to determine the impact of the algorithm on outcome. **Methods:** Consecutive patients with full-thickness penetrating rectal injury subsequent to the development of the algorithm were evaluated. Intraperitoneal rectal injuries (IP) were defined as wounds confined to the serosalized portion of the rectum. Injuries to the extraperitoneal rectum (EP) were defined as wounds involving the portion of the rectum not covered with serosa. Infectious complications (wound infection, bacteremia, intraabdominal abscess, retroperitoneal abscess) were compared between the ALG and PS groups. **Results:** 54



patients were identified. Demographics, injury severity, and preventive antibiotics (24hr) were similar between groups. Overall infectious complication rate was 14% in the ALG group versus 31% in the PS group (p < 0.05). Most striking was the zero incidence of retroperitoneal abscess in the ALG group versus 11% of the total infectious complications in the PS group. **Conclusions:** Implementation of the algorithm resulted in a significant decrease in infectious morbidity. Management by anatomic distinction allows for omission of colostomy in many IP injuries, and minimizes the risk of

retroperitoneal abscess in EP injuries with the selective application of presacral drainage.

Session I

Paper 4 8:50

**AGGRESSIVE SURVEILLANCE AND EARLY CATHETER DIRECTED
THERAPY IN THE PREVENTION OF ABDOMINAL COMPARTMENT
SYNDROME**

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M.D.*(EVMS) F.J. Cole, M.D.*(EVMS) J.N. Collins, M.D.*(EVMS)

Presenter: Scott F. Reed, M.D.

Invited Discussant: Michael F. Rotondo, M.D.

Background: Trauma patients are at risk for abdominal compartment syndrome (ACS). Our study aims at identifying these individuals early and placing an intra-abdominal catheter to reduce abdominal compartment pressure (ACP) before severe consequences of ACS occur. **Methods:** During a 5-month period we identified 8 patients who developed ACS. Patients who received 12 liters or more of IVF in the first 24 hours of their resuscitation, or received 500cc/hr of IVF for more than 4 consecutive hours were considered at-risk and had intra-abdominal pressure readings via bladder catheters every 4 hours. After resuscitation, patients were followed clinically and ACP readings were taken as necessary. When ACP exceeded 20mmHg or the abdominal perfusion pressure (APP = Mean arterial pressure (MAP) – ACP) fell below 50mmHg a diagnostic peritoneal lavage catheter was placed. Fluid volume and type, ACP, heart rate, MAP and pulmonary compliance were recorded. If adequate control of ACP was not achieved, the patients were managed with decompressive laparotomy. **Results:** Readings taken 30 minutes after placement of the peritoneal catheter showed an average decrease in ACP of 6.1mmHg (p-value 0.029), an increase in APP of 16.2mmHg (p-value 0.041), and an increase in MAP of 10.1 mmHg (p-value NS @ 0.064). Six of eight patients were managed non-operatively. Four patients failed to have their APP improve to >50mmHg with the catheter. Two of these patients underwent laparotomy, with one survivor, and two did not, dying of cerebral herniation and care withdrawal. Three of four patients requiring catheters in the first 32 hours of admission survived. All patients needing catheters after day 4 died, three within 24 hours. **Conclusions:** Intra-abdominal catheter placement is a reasonable first step in the management of ACS. Patients may be spared from progressing to significant ACS and the complications of an open abdomen. Late ACS may be prognostic of impending clinical deterioration. A prospective investigation at this institution is currently underway to determine if this method reduces overall morbidity and mortality.

TO CLOSE OR NOT TO CLOSE: CAN WE PREDICT DELAYED FASCIAL CLOSURE FOLLOWING DAMAGE CONTROL SURGERY?

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Presenter: Jeffrey M. Nicholas, M.D.

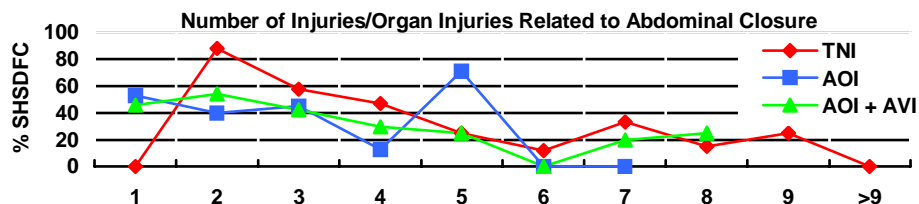
Invited Discussant: Rao R. Ivatury, M.D.

Objectives: To date no factors predict same hospital stay delayed fascial closure (SHSDFC) of the open abdomen. While SHSDFC is often successful it may result in abdominal compartment syndrome (ACS), fascial necrosis, or dehiscence. The objective of this study was to identify factors predicting SHSDFC following damage control surgery (DCS) that may guide open abdominal management (OAM). **Methods:** 180 trauma patients with OAM cared for between 5/1997 and 9/2003 were retrospectively reviewed by analyzing TRACS, operative reports, discharge summaries, and an M and M database. Results were analyzed by the Wilcoxon rank sum test and chi-square analysis. **Results:** 134 patients (74%) requiring OAM survived greater than 24 hours to return to the operating room (OR). Mortality and SHSDFC rates were:

N, (%)	Packing/DCS	1° ACS	2° ACS	FD/TP	Total
Total	97 (72)	10 (7.5)	20 (15)	7 (5.5)	134 (100)
Mortality	35 (36)	1 (10)	8 (40)	1 (14)	45 (34)
SHSDFC	35 (36)	5 (50)	6 (30)	0 (0)	46 (34)

FD = fascial dehiscence
TP = tertiary peritonitis

In 97 DCS patients age, transfusion, BD, ISS, RTS and abdominal vascular injury (AVI) did not predict SHSDFC (p = 0.96, 0.59, 0.63, 0.37, 0.59, 0.06), however total number of injuries (TNI) (p = 0.0009) and number of abdominal organ injuries (AOI) (p = 0.01) did.



Conclusions: TNI and number of AOI may predict SHSDFC following DCS at initial return to the OR guiding attempts at SHSDFC and OAM. AVI may also influence closure.

EARLY AGGRESSIVE CLOSURE OF THE OPEN ABDOMEN - A NEW APPROACH

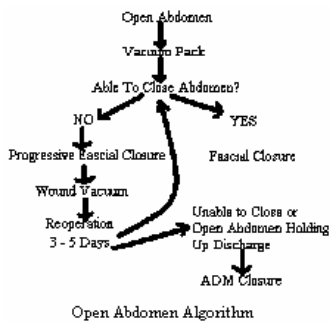
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Presenter: Bradford G. Scott, M.D.

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

Introduction: The open abdomen is traditionally closed either primarily or allowed to granulate, forming a planned ventral hernia. The aim of this study is to describe a new and aggressive approach to definitive closure of the open abdomen. **Methods:** A retrospective review of 37 patients who underwent definitive abdominal closure using a combination of vacuum pack, vacuum-assisted wound management and acellular dermal matrix. (ADM)



Results: All patients' open abdomens were maintained with vacuum assisted wound management in attempts for primary closure as per algorithm. Once it was determined that the abdomen would not close primarily; it was closed with ADM and skin advancement. The mean duration of the open abdomen was 21.7 days (range 6-45), with an average of 127.78 cm² of ADM, the largest number being 800 cm²,

with decreasing use of product later in the series. No major complications were seen with the repair. Superficial wound infection occurred with two patients that were easily treated with wet to dry dressing changes. No intraabdominal complications such as fistula or graft loss were seen. A single patient had an abscess drained below the ADM. All patients left the hospital with an intact abdominal wall and skin. All 37 patients survived to discharge and were seen in follow-up within one month. No early hernia formation was seen at the one month follow up with the longest at one year. No abdominal wall complications were seen in



subsequent follow up patients. Above are an open abdomen, ADM closure, and one week later showing incorporation. **Conclusion:** Early aggressive closure of the open abdomen is possible with ADM. Short term results are promising and warrant further study.

Session I

Paper 7 9:50

INCREASED INTRA-ABDOMINAL,INTRATHORACIC AND INTRACRANIAL PRESSURE AFTER SEVERE BRAIN INJURY:MULTIPLE COMPARTMENT SYNDROME

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Presenter: Thomas M. Scalea, M.D.

Invited Discussant: Vincente H. Gracias, M.D.

Objectives: Fluid therapy and/or acute lung injury (ALI) increases intraabdominal (IAP) and intrathoracic pressure (ITP) increasing intracranial pressure (ICP) after traumatic brain injury (TBI). Further fluid therapy to support cerebral perfusion or increasing ITP to treat ALI further increases ICP. This can create a cycle that ultimately produces multiple compartment syndrome (MCS). Both decompressive craniectomy (DC) and decompressive laparotomy (DL) decrease ICP. DL can also decrease IAP and ITP. We evaluated the serial application of DC and DL to treat MCS. **Methods:** Data was analyzed on 102 consecutive patients with severe TBI who underwent DC alone to decrease ICP or in combination with DL to treat MCS. **Results:** All 102 patients sustained blunt injury. 70% were male with a mean age of 29.5 years, ISS of 34.4, and admission GCS of 7.1. 51 patients had diffuse brain injury and fifty-one had mass lesions. 78 patients (76%) underwent DC alone. 24 (22%) had both therapies for MCS. 15 patients had DC prior to DL and 9 had DL prior to DC. Mean time between DC and DL was 3.4 ± 6 days. The mean IAP prior to DL was 28 ± 5 mmHg. Peak ITP was 44 mmHg and significantly decreased to 40mm HG after DL in the MCS group ($p=0.01$). Mean ICP decreased significantly after both DC and DL ($p<0.05$). **Conclusion:** Increased ICP may be from primary TBI or MCS. Patients with MCS have higher ISS, ICP's, and fluid needs, but no increase in mortality. MCS should be considered in patients with increased ICP that do not respond to therapy.

	DC	DC and DL	p-value
ISS	31 \pm 10	37.8 \pm 11*	0.02
Admission GCS	6.5 \pm 2.7	7.7 \pm 4	NS
Initial ICP	22 \pm 8 mmHg	20 \pm 10 mmHg	NS
Pre-DC ICP	23.6 mmHg	30.5 mmHg*	0.009
Post-DC ICP	14.1 mmHg	14 mmHg	NS
Pre-DL ICP	N/A	26 mmHg	
Post-DL ICP	N/A	19* mmHg	0.025
Fluid (first 7 days)	39.8 \pm 13 litres	63 \pm 21 litres*	<0.001
Mortality	24/78 (30.7%)	10/24 (42%)	NS

Session I

Paper 8 10:10

COMPUTED TOMOGRAPHIC ANGIOGRAPHY FOR THE DIAGNOSIS OF BLUNT CERVICAL VASCULAR INJURY: IS IT READY FOR PRIMETIME?

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Presenter: Alexander L. Eastman, M.D.

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

Introduction: The previously reported sensitivity of 2- and 4-channel detector computed tomographic angiography (CTA) for the diagnosis of blunt cervical vascular injury (BCVI) has been inadequate. We hypothesized that advances in CT technology have improved the diagnostic sensitivity of CTA at least to that of invasive catheter angiography (CA).

Methods: Data from all patients presenting to a Level I trauma center at risk for BCVI according to a modification of the Denver criteria were collected prospectively with IRB approval. Each patient was evaluated with CTA (using a 16-channel detector, GE Multislice Lightspeed Scanner with Advantage 4.1 3D workstation) and these findings were confirmed with standard CA of the head, neck and aortic arch. **Results:** Of 3010 trauma admissions over eight months, 148 were deemed at risk for BCVI. 135 patients received both CTA and CA, while 13 received CTA only. Reasons for this included refusal to consent for CA (N=10) and discharge prior to CA (N=3). 43 BCVIs were identified among 41 patients yielding an overall incidence of 1.4% and an incidence within the screened population of 30.4%. In 42 of 43 patients with BCVI, the results of CTA and CA were concordant. There was a single false-negative CTA in a patient with a grade I vertebral artery injury (VAI) that required no further intervention. The remaining 92 patients had normal CTAs confirmed by a normal CA. The overall incidence of carotid artery injury (CAI) was 0.6% (N=19) and VAI was 0.8% (N=24). 96% of VAIs (N=23) were associated with at least one cervical spine fracture. In the cohort that received both studies, the sensitivity of CTA in detecting CAI was 100% and VAI was 96.0%. The overall sensitivity, specificity, positive predictive value, negative predictive value and accuracy of CTA for BCVI were 97.1%, 100%, 100%, 98.9% and 99.3% respectively.

Conclusions: CTA, using a 16-channel detector, can be used to accurately screen at-risk patients for BCVI with sensitivity comparable to that previously reserved for CA. While additional study is needed, screening CTA may obviate the need for more invasive studies.

Session I

Paper 9 10:30

**16-SLICE CT-ANGIOGRAPHY IS A RELIABLE NONINVASIVE TEST THAT
ALLOWS LIBERAL SCREENING FOR BLUNT CEREBROVASCULAR
INJURIES**

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Presenter: Walter L. Biffl, M.D.

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

Screening for blunt cerebrovascular injuries (BCVI) detects many asymptomatic injuries. However, it has not been proven to prevent strokes, and thus many centers have been reluctant to implement screening protocols. It is particularly difficult to justify because four-vessel cerebral arteriography (ART), the gold standard diagnostic test, is invasive and resource-intensive. Noninvasive diagnostic modalities would allow more liberal screening with less risk to patients. Unfortunately, preliminary studies comparing computed tomographic angiography (CTA) with ART found that CTA missed clinically important injuries. However, CTA technology has advanced and offers image quality comparable to ART. In the absence of prospective comparative trials- which have little support at this time- data on the efficacy of CTA-based protocols are needed. We implemented a liberal screening protocol employing 16-slice CTA. The purpose of this study was to review our experience. **Methods:** A protocol called for CTA in all trauma patients with cranial or cervical trauma undergoing CT scanning. Any abnormality was further investigated with ART. Patients were followed for neurologic changes. Records were reviewed to determine whether clinically important injuries were missed by CTA. ART and CTA images were compared. **Results:** From June 2004-February 2005, 225 CTAs were performed. 15 (7%) patients were diagnosed with BCVI: 11 carotid (Grade II in 7, III in 3, and IV in 1) and 6 vertebral (Grade II in 2, IV in 3, and V in 1) injuries. CTA did not miss any clinically important BCVI. CTA was felt to offer superior imaging detail compared with ART. One patient without indications for screening (thoracic and lower extremity injuries) suffered stroke associated with a grade III carotid injury. **Conclusions:** 16-slice CTA offers excellent noninvasive imaging of BCVI. Avoidance of ART- and the yield of 7%- favor liberal screening for BCVI. A multicenter trial is warranted to corroborate these findings. Furthermore, a multicenter analysis should seek to identify additional risk factors for BCVI, such as significant thoracic trauma.

Session I

Paper 10 10:50

EVALUATION OF MULTISLICE HELICAL COMPUTED TOMOGRAPHIC ANGIOGRAPHY IN THE DETECTION OF LOWER EXTREMITY VASCULAR INJURY

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Presenter: Kenji Inaba, M.D.

Invited Discussant: Eric R. Frykberg, M.D.

Background: With the evolution of Multislice Helical CT Angiography (MCTA), the optimal imaging modality for arterial injury in the traumatized lower extremity has been challenged. The objective of this study was to evaluate the ability of MCTA to detect arterial injury in the traumatized lower extremity. Our hypothesis was that MCTA is a sensitive and specific test for the non-invasive evaluation of lower extremity arterial injury.

Methods: After IRB approval, we reviewed all patients at our Level 1 Trauma Center who sustained lower extremity trauma and underwent initial evaluation by MCTA over a 3 year period ending in 2/05. MCTA accuracy was tested against a gold standard of operative intervention, duplex ultrasonography, catheter based angiography or clinical follow-up.

Results: 63 MCTAs were performed in 59 patients. MCTA was diagnostic in 62 of the 63 scans (98.4%). The mechanism was penetrating in 45.8%. Lower extremity fractures were present in 38.7% of patients studied. There were 22 positive studies. Out of this group, 19 were confirmed at operation and 3 were managed non-operatively. In the 19 injuries confirmed in the operating theater, there were 5 superficial femoral, 2 profunda, 10 popliteal, 1 mid calf 3 vessel injury and 1 trifurcation injury. There were 2 trifurcation injuries managed non-operatively and there was 1 popliteal occlusion with distal reconstitution that was confirmed by duplex and managed non-operatively due to patient refusal of surgery. Forty studies were negative for arterial injury with clinical follow up available in 92.5% for a mean of 48.2 days (range 5-287 days). No missed injuries were identified during the follow-up period. MCTA was non-diagnostic in 1 patient (1.6%) secondary to artifact from retained missile fragments. MCTA achieved 100% sensitivity and 100% specificity in detecting clinically significant arterial injury.

Conclusion: Multislice CTA is a sensitive and specific non-invasive imaging modality for arterial evaluation in the injured lower extremity that may replace catheter based angiography in most patients.

**RISK FACTORS FOR FAILURE OF VENOUS THROMBOEMBOLISM
PROPHYLAXIS**

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Presenter: Bruce Potenza, M.D.

Invited Discussant: M. Margaret Knudson, M.D.

Objective: To perform a quality improvement initiative to determine the incidence and patient population at risk for failure of venous thromboembolism (VTE) prophylaxis.

Methods: A 4 year retrospective study of a level 1 trauma center was undertaken to identify those patients who developed VTE (deep vein thrombosis or pulmonary emboli). All patients were subject to a graduated VTE prophylaxis protocol encompassing; pneumatic compression stockings, subcutaneous heparin, oral anticoagulation and the placement of an inferior vena cava filter depending upon patient risk stratification.

Results: During the 4 year period there were 7,734 patients admitted to the trauma center. There were 1,522 (20%) seriously injured patients, defined as Injury Severity Score of 15 or greater. Of these, 84 (5.5%) developed VTE; 72 (4.7%) patients developed a deep vein thrombosis and 12 (0.8%) patients developed pulmonary emboli (1 death). Failures of VTE prophylaxis can be categorized into four groups: 1) 32 patients with pelvis and/or long bone fractures, 2) 25 patients with severe multisystem trauma, 3) 16 patients with isolated closed head injuries (mean GCS 9) and 4) 11 patients with spinal cord injury. The mean time (days) and rank order of VTE presentation was **group 1**(10.7), **3**(12.7), **2**(16.6) and **4**(18.2). 87% of all pulmonary emboli occurred in groups 1 & 2. Duplex screening was positive in only 10% of all PE. The greatest variation for prophylaxis and risk for VTE (1.25-3 fold increase) was in the patients undergoing multiple orthopedic procedures.

Conclusion: The most common risk factor for VTE appears to be the lack of prophylactic subcutaneous heparin (61 patients). (70%) had contraindications to receiving heparin (intracranial bleeding, thoracic, abdominal or pelvic hemorrhage). VTE prophylaxis in 4 spinal cord injured patients (65% compliance) could have been improved. The decision as to when to use heparin after surgical procedures is one of the greatest problems in achieving desired prophylaxis. Earlier anticoagulation or improved prophylactic techniques in these high risk patients may offer the only way to decrease the incidence of VTE.

ERYTHROPOIETIN-A (EPO-A) USE AND THE RISK OF THROMBOTIC VASCULAR EVENTS IN TRAUMA PATIENTS

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David Beaudreault BS
Amy Boudreault MD
Kathryn Lindsay MEd, RN, CEN, CCRN
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Presenter: Lonnie Frei, M.D.

Invited Discussant: John T. Owings, M.D.

Background: Transfusion therapy is associated with risks including reactions, infections and immunosuppression. Limiting transfusions is one of the goals for patients, and one of the methods is the use of Erythropoietin-alpha (Epo-a) for marrow stimulation and endogenous blood cell production. In the oncology population the use of Epo-a has been associated with an increased risk of venous thrombotic events (VTE) . This study evaluates the occurrence of thrombotic events in trauma patients receiving Epo-a.

Study design: A retrospective study was performed using the trauma registry and chart reviews for 2003. Patients were evaluated for risk factors for VTE development, including Epo-a administration, and statistical analysis was performed.

Results: There were a total of 1862 patients admitted to the registry for 2003. Of these, 170 patients received Epo-a. There were 14 episodes of VTE in the Epo-a group for an incidence of 8.2%, as opposed to only 10 VTE episodes in the remaining 1592 patients, an incidence of 1.6%. In the Epo-a group there was a statistically significant dose-dependent increase in the risk for development of VTE.

Conclusion: Epo-a appears to be associated with a dose-dependent increase in VTE. This increased risk was independent of other risk factors evaluated in this study. The risk of VTE in our trauma population was lower than national averages (7-58%), but is nonetheless increased in patients receiving Epo-a. This research suggests that guidelines may need to be established to minimize the risk of VTE in trauma patients receiving Epo-a.

**TIMING OF PULMONARY EMBOLI:
IMPLICATIONS FOR OPTIONAL VENA CAVA FILTERS**

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Edmund J. Rutherford, MD*; Stephanie Dix, BS.
University of North Carolina at Chapel Hill

Presenter: Ronald F. Sing, D.O.

Invited Discussant: Frederick B. Rogers, M.D.

Background: Recent reports of the retrieval of optional vena cava filters (VCF) in trauma patients had average implant durations of 10 and 19 days.(1,2) However, no evidence-based guidelines exist on the appropriate time to remove them. Our purpose was to examine the timing of pulmonary emboli (PE) to determine the optimal timing to remove optional VCFs. **Methods:** A multi-center (4 Level I trauma centers) retrospective chart review of trauma patients who had a post-injury PE between January 2000 and December 2004 was performed. We examined the demographics, thromboembolic prophylaxis use at the time of PE (pharmacologic [PHARM] or sequential compression devices [SCD]), diagnostic test used, timing of PE related to the date of injury, and survival outcome.

Results: 146 patients were identified, mean age 45.1 (\pm 21.1 SD); ISS 18.0 (\pm 12.1 SD).

Diagnosis was obtained by spiral CT (N=93), pulmonary arteriogram (N=6), V/Q (N=26), autopsy (N=6), clinical (N=6), and

PE Occurrence	Frequency (N)	%
<7 days	79	54.1
7-14 Days	43	29.4
15-21 Days	8	5.5
22-28 Days	8	5.5
>28 Days	8	5.5

unknown (N=3). Overall mortality 17.8% (N=26). PE was felt to contribute to or was cause of death in 22 (85%). Two late PE deaths occurred (Days 21 and 43). Sixty (37%) patients had PHARM prophylaxis at the time of PE and 83 (50.9%) had SCDs. Time from injury to PE was 7.9 days (\pm 8.1 SD), the longest 43 days post-injury. **Conclusions:** 11% of PE occur after 21 days, including fatal PE. Clinical criteria must be developed to determine the optimal time to remove optional VCFs without exposing patients to the risk of PE by removing a filter too soon.

¹Morris CS, Rogers FB, Najarian KE, Bhave AD, Shackford SR. Current trends in vena caval filtration with the introduction of a retrievable filters at a level I trauma center. J Trauma 2004;57:32-36.

²Hoff WS, Hoey BA, Wainwright GA, Reed JF, Ball DS, Ringold DS, Grossman MD. Early experience with retrievable inferior vena cava filters in high-risk trauma patients. J Am Coll Surg 2004;199:869-874.

THE ROLE OF RETRIEVABLE VENA CAVA FILTERS IN PREVENTING PULMONARY EMBOLISM IN TRAUMA PATIENTS: A CAUTIONARY TALE

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Presenter: Jared L. Antevil, M.D.

Invited Discussant: Karen J. Brasel, M.D., M.P.H.

Background: Retrievable vena cava filters (RF) offer the appeal of short-term prophylaxis for trauma patients temporarily at risk for pulmonary embolism (PE) without the long-term risks of permanent vena cava filters (PF). However, the evidence that either RF or PF reduce the risks of PE and death in trauma patients is not conclusive. RF were introduced at our trauma center in September, 2002. The purpose of this study was to evaluate the effects of RF on our strategy to prevent PE in trauma patients.

Methods: We reviewed our trauma registry to compare rates of filter placement, filter-related complications (FRC), and PE before (Group I – January, 2000 through August, 2002) and after (Group II – September, 2002 through December, 2004) RF introduction. Indication for filtration, filter retrieval, FRC, and incidence of PE were compared.

Results:

	Patients with Filters	Pulmonary Embolism	Major FRC
Group I (n = 5,042)	54 (1.1%)	8 (0.2%)	1 (1.9%)
Group II (n = 5,038)	163 (3.2%)	10 (0.2%)	5 (3.1%)
P value	< 0.001	0.636	0.658

The risk profile for PE was similar in the two groups. Major FRC included two vena cava thrombotic occlusions, two filter infections with sepsis, one filter lodged in the jugular vein during retrieval, and one PE after filter placement. RF removal was attempted in 38 (23.3%) patients and successful in 32 (19.6%) for a retrieval rate of 84.2%.

Conclusion: The advent of RF was associated with a three-fold increase in vena cava filter placement in our trauma center. Major FRC were encountered and a very low incidence of PE was not altered by their use. Successful removal could be verified in only 19.6% of RF. The results of this study lead us to question the rationale for a more liberal use of vena cava filters in trauma patients.

PREDICTIVE VALUE OF BRONCHO-ALVEOLAR LAVAGE FLUID GRAM STAIN IN THE DIAGNOSIS OF VENTILATOR ASSOCIATED PNEUMONIA: A PROSPECTIVE STUDY

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Presenter: Aaron E. Goldberg, B.S.

Invited Discussant: Martin A. Croce, M.D.

Objective: Quantitative broncho-alveolar lavage (qBAL) is increasingly being utilized for diagnosing ventilator associated pneumonia (VAP). The current study prospectively evaluates the accuracy of BAL fluid Gram stain (GS) in predicting 1) the presence of VAP and 2) predicting the class of causative organism, in patients suspected of VAP.

Methods: Patients suspected of VAP in a trauma/surgical ICU underwent bronchoscopic qBAL with GS. Presence and class of organisms seen on GS were correlated respectively with the presence of VAP, as diagnosed by qBAL, and class of causative organism. VAP was defined as qBAL >10⁵ organisms/ml. All data was gathered prospectively.

Results: During the 28 month study period ending May 2004, 162 patients underwent 217 qBALs for suspected VAP. 43 (20%) specimens were positive for VAP. 33 specimens (77%) had 1 causative organism, 8 (18%) had 2, and 2 (5%) had 3. 24 of 39 (62%) specimens showing moderate or many organisms on GS were positive for VAP. However,

Table I	GS micro-organisms			
	None (n=122)	Few (n=56)	Mod. (n=12)	Many (n=27)
VAP	4(3%)	15(27%)	8(67%)	16(59%)

Table II	G+ VAP	G- VAP	G+&G- VAP
G+ only (n=22)	17(77%)	3(14%)	2(9%)
G- only (n=4)	0	3(75%)	1(25%)
G+ & G- (n=13)	2(15%)	5(39%)	6(46%)
None (n=4)	1(25%)	3(75%)	0

4 of 122 (3%) specimens showing none and 15 of 56 (27%) showing few organisms on GS were also positive for VAP (Table I). Of the 39 qBAL specimens positive for VAP and where the GS showed organisms, 5 of 22 (23%) showing

only G+ organisms on GS had G- VAP (G- alone: 3; G+ and G-: 2), and 1 of 4 (25%) showing G- organisms only had G+ and G- VAP. Of the 4 qBAL specimens positive for VAP where the GS did not show organisms, 1 had G+ and 3 had G- VAP (Table II).

Conclusions: BAL fluid GS is poor in predicting the presence of VAP and predicting the class of causative organism. Utilizing GS to determine necessity of and select class of anti-microbial therapy will result in delayed and/or inappropriate VAP therapy.

**A PRACTICAL APPLICATION OF PRACTICE BASED LEARNING:
DEVELOPMENT OF AN ALGORITHM FOR EMPIRIC ANTIBIOTIC
COVERAGE IN VENTILATOR ASSOCIATED PNEUMONIA**

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Department of Surgery

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Presenter: Preston R. Miller, M.D.

Invited Discussant: Philip S. Barie, M.D., M.B.A.

Introduction: Development of practice based learning (PBL) is one of the core competencies required for resident education by the Accreditation Council for Graduate Medical Education, and specialty organizations including the American College of Surgeons have formed task forces to understand and disseminate information on this important concept. Translating this concept into daily practice may be difficult, however. Our goal was to describe the successful application of PBL to patient care improvement with development of an algorithm for the empiric therapy of ventilator associated pneumonia (VAP). **Methods:** The algorithm development occurred in 2 phases. In phase1, the microbiology and timing of VAP as diagnosed by bronchoalveolar lavage was reviewed over a 2 year period to allow for recognition of patterns of infection. In phase 2, based on these data, an algorithm for empiric antibiotic coverage that would ensure that the large majority of patients with VAP received adequate initial empiric therapy was developed and put into practice. The period of algorithm use was then examined to determine rate of adequate coverage and outcome. **Results:** Phase 1: From 1/1/00-12/31/01, 110 patients were diagnosed with VAP. Analysis of microbiology revealed a sharp increase in the recovery of nosocomial pathogens on post-injury day 7 (19% < day 7 vs. 47% ? day 7, p=0.003.). Adequate initial antibiotic coverage was seen in 74%. Phase 2: An algorithm employing Ampicillin-Sulbactam for coverage of community acquired pathogens prior to day 7 and Cefipime for nosocomial coverage ? day7 was then employed from 1/1/02-12/31/03. Evaluation of 186 VAP cases during this interval revealed a similar distribution of nosocomial cases (16% < day 7 vs. 64% ? day 7, p<0.0001.). Empiric antibiotic therapy was adequate in 82% of cases < day 7 and 85% of cases ? day 7: overall accuracy improved to 83%(p=0.032). Mortality from phase 1 to phase 2 trended toward a decrease (21% vs. 13%, p=0.1). **Conclusions:** Application of the concept of PBL allowed for identification of local patterns of infection and development of an institution specific treatment algorithm that resulted in > 80% adequate initial empiric coverage for VAP with a trend toward decreased mortality. PBL allows for alteration in practice based on local patterns and outcomes and has the potential to improve patient care.

THE FUTILITY OF CPIS IN TRAUMA PATIENTS

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Presenter: Martin A. Croce, M.D.

Invited Discussant: Wendy L. Wahl, M.D.

INTRODUCTION: The clinical pulmonary infection score (CPIS) has received much attention recently. Advocates have touted its use for the diagnosis and duration of therapy in patients with ventilator associated pneumonia (VAP). However, little has been written about its utility in trauma patients. The clinical, physiologic, and radiologic components of the CPIS may be difficult to differentiate from the systemic effects of injury. Quantitative cultures of the lower airway have been shown to be efficacious in differentiating VAP from the systemic inflammatory response syndrome (SIRS). In this study, we evaluated the potential use of CPIS as the sole means for diagnosis of VAP in critically injured patients.

METHODS: Patients were identified from the VAP database maintained in our level I trauma center. Only those who had CPIS calculated at the time of bronchoscopy with BAL were included. VAP required $\geq 10^5$ colonies / mL on quantitative BAL for diagnosis. Antibiotic therapy was based on quantitative BAL results. Patients with $< 10^5$ colonies / mL were diagnosed with SIRS. Sensitivity and specificity of a CPIS > 6 for VAP diagnosis (confirmed by BAL) were calculated.

RESULTS: 113 patients (average age 41, ISS 28, APACHE II 15, GCS 11, 90% blunt injury) underwent 195 BALs. The overall incidence of VAP was 38%. The table compares patients with episodes of VAP and SIRS.

	N	Age	ISS	APACHE II	GCS	CPIS
VAP	75	44	26	13.2	11.9	7.0
SIRS	120	39	29	16.8	10.1	6.9

There were no statistical differences between groups. Using a CPIS > 6 as the threshold for VAP, its sensitivity was 65% and specificity was 41%.

CONCLUSIONS: CPIS cannot differentiate VAP from SIRS in critically injured patients. Using CPIS to initiate antibiotic therapy in trauma patients could be harmful. Whether CPIS is useful to determine duration of antibiotic therapy is unknown.

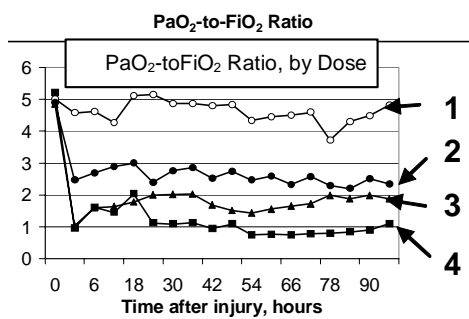
ACUTE RESPIRATORY DISTRESS SYNDROME SECONDARY TO INHALATION OF CHLORINE GAS

LC Cancio*, MD; AI Batchinsky, MD; DK Martini, MS; BS Jordan, MSN; EJ Dick, DVM; J Fudge, DVM; CA Baird, RVT; M Lucas, RVT; DE Hardin.

Presenter: Leopoldo C. Cancio, M.D.

Invited Discussant: Saman Arbabi, M.D.

Objective: To characterize the acute respiratory distress syndrome (ARDS) caused by chlorine gas (Cl_2). **Background:** Toxic industrial chemicals (TICs) have recently been identified as potential terrorist weapons. Several TICs act primarily on the respiratory tract, but more work is needed to define the pathophysiology and treatment of these injuries. **Methods:** Anesthetized female sheep (n=35, 42.4 kg \pm 5.4 SD) were ventilated with 300 L of a Cl_2 /air/oxygen mixture over 30 min. Doses were: 0 ppm (Control, Group 1); 120 ppm (Low Dose, Group 2); 240-350 ppm (Medium, Group 3); and 400-500 ppm (High, Group 4). After injury they were maintained for 96 h in an animal ICU. Gentle mechanical ventilation (peak airway pressure < 40 cmH₂O) was required to limit barotrauma. Cardiopulmonary data were collected every 6 h, and CT scans daily. The multiple inert gas elimination technique (MIGET) was used to characterize the etiology of hypoxemia. **Results:** Lung function was well maintained in Group 1; Cl_2 caused



immediate and sustained acute lung injury (PaO₂-to-FiO₂ ratio, PFR<300) in Group 2, and ARDS (PFR<200) in Groups 3-4 (see Figure; ANOVA p<.0001 between/within groups). Cl_2 also rapidly caused hypotension and decreased cardiac output, lasting 48 h in survivors. All animals in Groups 1-2 survived 96 h. Kaplan-

Meier analysis showed dose-related differences in survival (Log Rank test, p<.0001). Logistic regression identified 280 ppm as the lethal dose 50%. CT and histopathology demonstrated lesions of both small airways and alveoli. MIGET showed diversion of blood flow from normal to true-shunt lung segments. **Conclusions:** Cl_2 causes severe, dose-related lung injury, with features seen in both smoke inhalation (small airway lesions)

ACUTE RENAL FAILURE (ARF) IN CRITICALLY ILL SURGICAL PATIENTS: PERSISTENT LETHALITY DESPITE NEW MODALITIES OF RENAL REPLACEMENT THERAPY

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Presenter: Soumitra R. Eachempati, M.D.

Invited Discussant: Patrick J. Offner, M.D.

Objective: Despite improved resuscitation and sepsis care, acute renal failure (ARF) remains common in SICU pts. New methods of renal replacement therapy (RRT), including high-flux hemodialysis (HD) and continuous RRT, are increasingly used early during ARF, but data are scant to suggest that mortality (M) is improved. We hypothesized that M for ARF pts. is lower with modern RRT. **Methods:** Pts. with ARF ([Scr] \geq 2.4 mg/dL) in the SICU from 1993-2004 were identified for prospective data collection in ongoing studies of multiple organ dysfunction (MOD) syndrome, including calendar year, age, gender, APACHE III score (AIII), cumulative MOD score and component scores, non-renal OD score (MODnr), and need for HD/CRRT. Pts. were stratified 1/94-1/01 (pre-CRRT) and 2/01-12/04 (post-CRRT). Analysis: χ^2 , ANOVA, logistic regression (LR), $X \pm$ SEM. * $p < 0.05$. **Results:** 530/8,619 pts. (6.1%) (41% female) developed ARF, 311 of whom were treated pre-CRRT. Mean age was 69 ± 1 years. Mean AIII was 81 ± 2 . 15.7% of patients with ARF received HD, with no difference over time (13.5% vs. 18.7%). CRRT was performed in 17.3% of pts. after 2/01. Overall M was 46% (AIII-predicted M: 55%) with no difference over time (46% vs. 45%, $p = 0.86$). AIII for RRT patients was 91 with M of 61% (AIII-predicted M: 67%), with no difference over time (61% vs. 62%). LR for M (Table) fits the data well (Model χ^2 ? ? $\beta = 0.3$).

Parameter (N)	Lived (287)	Died (243)	OR (95% CI)
HD			0.341 (0.160-0.728)*
CRRT			2.184 (0.813-5.871)
Age	68.1 ± 0.8	70.6 ± 0.9	1.028 (1.012-1.046)*
Renal	2.6 ± 0.1	3.1 ± 0.1	1.758 (1.278-2.416)*
Cardiovascular	1.3 ± 0.1	3.0 ± 0.1	1.476 (1.184-1.840)*
Hepatic	0.3 ± 0.1	1.4 ± 0.1	1.697 (1.331-2.164)*
Neurologic	1.1 ± 0.1	3.1 ± 0.1	2.039 (1.649-2.522)*

Conclusions: Despite modern RRT, the M of ARF in SICU pts. remains high, due partly to MODnr. M was lower with conventional HD, therefore patients who need RRT should be treated preferentially with HD if their physiologic status permits.

**VALIDATION OF PHYSIOLOGIC END-POINTS OF RESUSCITATION:
STROKE WORK AND VENTRICULAR-ARTERIAL COUPLING**

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Presenter: R. Shayn Martin, M.D.

Invited Discussant: Jeffrey S. Young, M.D.

Introduction: Successful shock resuscitation after severe injury has been associated with decreased multiple organ failure and mortality rates. We have previously demonstrated improved survival by maximizing stroke work index (SWI) and ventricular-arterial coupling (VAC).* Improved VAC is demonstrated by a lower ratio of aortic input impedance (Ea) and ventricular contractility (Ees). The purpose of this study was to examine the reproducibility of these findings in an independent dataset from another institution. **Methods:** Severely injured patients requiring a pulmonary artery catheter for acute resuscitation were included in the study. Patients with severe head injury were excluded. Using recently developed technology that allows continuous sampling, hemodynamic (HD) data was acquired, stored, and retrospectively analyzed. Mean values of HD variables were compared between survivors and non-survivors. Receiver operator curves (ROC) were constructed for HD variables. Threshold values which maximized sensitivity and specificity were determined. **Results:** 88 patients over a 19 month time period (2.4 million samples) met study criteria. Survivors demonstrated significantly better mean arterial pressure (MAP), cardiac index (CI), SWI, and RATIO (Ea/Ees) (See Table). The ROC area under the curve (AUC) for SWI and RATIO were substantially greater than for MAP and CI.

Conclusions: Using a new dataset from a different institution,

Variable	Survivors	Non-Surv	P	AUC	Threshold
MAP (mmHg)	87.1 ± 10.5	79.3 ± 11.7	0.01	0.69	82
CI (L/min/m ²)	4.3 ± 1.1	3.7 ± 1.0	0.04	0.67	3.6
SWI(mmHg•mL/m ²)	4421 ± 1278	3163 ± 1066	0.0008	0.78	3250
RATIO (Ea/Ees)	1.9 ± 1.1	2.9 ± 1.0	0.002	0.82	2.1

this study confirms our findings that improved SWI and VAC are associated with greater survival. SWI and RATIO demonstrate excellent AUC measurements suggesting their usefulness in predicting mortality. These data support the recommendation of 3250 for SWI and 2.1 for RATIO as proposed markers of adequate cardiovascular performance during resuscitation.

* *J Trauma* 1998; 45:470-8

COMBINATION OF RECOMBINANT HUMAN GROWTH HORMONE (RHGH) AND PROPRANOLOL DECREASES HYPERMETABOLISM AND INFLAMMATION IN SEVERELY BURNED CHILDREN

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University of Texas Medical Branch and Shriners Burns Hospitals for Children

Presenter: Marc G. Jeschke, M.D., Ph.D.

Invited Discussant: Richard L. Gamelli, M.D.

Background: The combination of recombinant human growth hormone (rhGH) plus propranolol improves muscle protein synthesis in severely burned pediatric patients. Therefore we hypothesized that rhGH plus propranolol will decrease hypermetabolism, acute phase proteins and inflammatory mediators after a massive burn.

Patients and Methods: Fifteen thermally injured pediatric patients with burns larger than 40% TBSA, 0.1 to 16 years of age, admitted within 7 days after burn received rhGH (0.2 mg/kg/day) and propranolol (to decrease heart rate by 20%) for at least 25 days. Fifteen children were matched for burn size, age, gender, inhalation injury and infection and served as controls. Outcomes measures included resting energy expenditure, serum constitutive proteins, acute phase proteins and cytokines. Statistical analysis was performed by un-paired and paired Student's t-test and ANOVA with Bonferroni's correction where appropriate.

Results: Both cohorts were similar in age, burn size, gender and accompanying injuries. Percent predicted REE significantly decreased in patients receiving rhGH/propranolol ($\Delta -4 \pm 8\%$) compared to controls ($\Delta +40 \pm 24\%$), $p < 0.05$. RhGH/propranolol administration significantly decreased serum IL-1 β , IL-6, IL-7, IL-13 and GM-CSF when compared to controls, $p < 0.05$. RhGH/propranolol increased serum IGF-I and IGFBP-3, retinol-binding protein and transferrin, while rhGH/propranolol decreased serum C-reactive protein and haptoglobin, when compared to placebo, $p < 0.05$. Free fatty acids that are known to increase with rhGH treatment were not significantly increased in the rhGH/propranolol group compared to controls.

Conclusion: Recombinant human growth hormone in combination with propranolol attenuates hypermetabolism which is reflected in decreased pro-inflammatory cytokine and protein concentration without an increase in free fatty acids.

HYPERTONIC LACTATED SALINE RESUSCITATION REDUCES THE RISK OF ABDOMINAL COMPARTMENT SYNDROME IN SEVERELY BURNED PATIENTS

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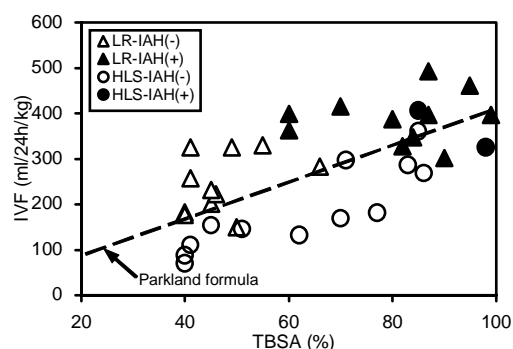
Presenter: Jun Oda, M.D.

Invited Discussant: Steven R. Shackford, M.D.

Background: Secondary abdominal compartment syndrome (ACS) is a lethal complication after resuscitation from burn shock. Hypertonic lactated saline (HLS) infusion reduces early fluid requirements in burn shock, however, the effects of HLS on intra-abdominal pressure have not been clarified. **Methods:** Patients admitted to our burn unit between 2002 and 2004 with burns greater than or equal to 40 percent of the total body surface area (TBSA) without severe inhalation injury were entered into a fluid resuscitation protocol using HLS (n=14) or lactated Ringer's (LR, n=22) solution. Urine output (UO) was monitored hourly with a goal of 0.5 to 1.0 ml/kg/h. Hemodynamic parameters, blood gas analysis, intra-bladder pressure as an indicator of intra-abdominal pressure (IAP), and peak inspiratory pressure (PIP) were recorded. Pulmonary compliance (C_{dyn}) and abdominal perfusion pressure (APP) were calculated. **Results:** Thirteen of 36 patients developed intra-abdominal hypertension (IAH) requiring decompression in 20.8±7.2 hours. In the HLS group, the amount of intravenous fluid (IVF) volume to maintain adequate UO was less, and peak IAP, PIP at 24 hours after injury were significantly lower than those in the LR group. APP was maintained higher level in the HLS group. **Conclusion:** In patients with severe burn injury, large IVF volume decreases abdominal perfusion during the resuscitative period because of increased IAP. Our data suggest that HLS resuscitation could reduce the risk of secondary ACS with lower fluid load in burn shock patients.

At 24hours postburn	LR (n=22)	HLS (n=14)
%TBSA burned	64.2 ± 20.4	66.7 ± 20.1
IVF (mL/kg/%TBSA)	5.2 ± 1.2	3.1 ± 0.9 *
Peak IAP (cmH ₂ O)	31.1 ± 20.9	14.8 ± 11.1 *
PIP (cmH ₂ O)	42.4 ± 16.8	30.2 ± 10.3 *
C _{dyn} (mL/cmH ₂ O)	15.5 ± 9.5	26.2 ± 11.5 *
APP (mmHg)	62.5 ± 19.4	93.0 ± 21.2 *
UO (mL/h/kg)	0.95 ± 0.48	0.96 ± 0.48
Hematocrit (%)	42.6 ± 6.4	44.4 ± 6.9
PaO ₂ /F _i O ₂ ratio	273 ± 134	361 ± 134 *

Data are expressed as means ± SD. * p < 0.05.



METABOLIC CHANGES OF SEVERELY BURNED CHILDREN

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Shriners Burns Hospital for Children
University of Texas Medical Branch

Presenter: Rene Przkora, M.D.

Invited Discussant: William G. Cioffi, M.D.

Background: Major trauma and burns are associated with whole body catabolism and hypermetabolism which persists over several months. The aim of the present study was to assess the effect of time on whole body metabolism and regeneration in massively burned children.

Methods: Pediatric patients with greater than 40% total body surface area burn (TBSA) were enrolled in the study and followed clinically for 24 months after injury. At discharge, 6, 9, 12, 18, and 24 months after burn injury height, weight, body composition (DEXA) and resting energy expenditure (REE) were measured. Statistical analysis was performed using ANOVA followed by Tukey, with significance accepted at $p < 0.05$. Body composition results were compared to normal, unburned children.

Results: Thirty children were studied. Lean body mass (LBM), fat mass, bone mineral content (BMC), and weight increased significantly over 24 months (ANOVA, $p < 0.05$), whereas no changes were seen in height, and bone mineral density (BMD). Looking at each time point, LBM was significantly improved at 24 months compared to 6, 9, and 12 months post burn (Tukey, $p < 0.05$) and reached normal values compared to unburned children. Significant increases in fat mass occurred when comparing 24 months to 6 and 9 months post burn. Bone mineral content results were significantly higher comparing 24 and 6 months post burn, whereas body weight improved significantly at 24 months compared to 6, 9, and 12 months post burn. Percent predicted REE was significantly decreased at 24 and 18 months compared to 6, 9 and 12 months post burn and was normal compared to unburned children at 24 months after injury.

Conclusions: Body regeneration after severe burns in children requires up to 24 months and demonstrates the need for long-term rehabilitation in these patients.

**INCREASED TOLL-LIKE RECEPTOR (TLR) 4 EXPRESSION ON T CELLS
MAY BE A MECHANISM FOR ENHANCED T CELL RESPONSE LATE
AFTER BURN INJURY**

Bruce A. Cairns MD, FACS
Robert Maile, PhD
Carie Barnes, BS
Anthony A. Meyer, MD, PhD *

Presenter: Bruce A. Cairns, M.D.

Invited Discussant: David W. Mazingo, M.D.

Objective: Burn injury is associated with a dynamic T cell response. We have previously reported that there is an enhanced functional immune response by splenic T cells 14 days after burn injury that is mediated by the accumulation of activated memory-like CD8⁺ T cells. Recent reports suggest that activated, but not naïve, T cells express the innate Toll-like receptor (TLR) 4 resulting in an enhanced T cell response. Therefore we hypothesized that increased TLR4 expression on T cells may be a mechanism for enhanced T cell response 14 days after burn injury.

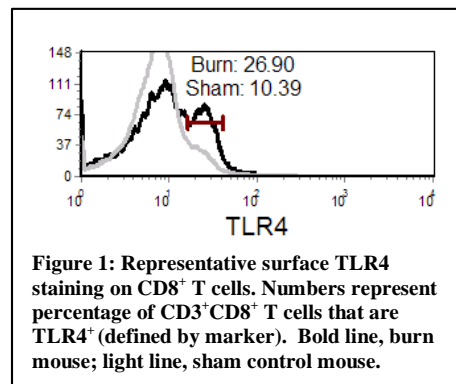
Methods: Splenocytes were harvested from wildtype B6 mice 14 days after 20% TBSA burn or sham. Splenocytes *ex vivo* were surface stained with monoclonal anti-CD3 and anti-TLR4 antibodies, as well as anti-CD4 or anti-CD8 antibodies and analyzed by flow cytometry.

	Burn	Sham
CD4	29.17±3.6*	22.42±0.6
CD8	19.03±3.8*	10.57±0.7

Table 1: Table of mean percentage±SEM of CD3⁺CD4⁺ or CD3⁺CD8⁺ T cells that are TLR4⁺; *, p<0.05 by Students t test.

Results: Burn mice had significantly increased number of both CD3⁺CD8⁺ and CD3⁺CD4⁺ T cells (Table) expressing higher levels of TLR4 compared to sham (Figure).

Conclusion: This study demonstrates that burn injury induces an increase in the number of TLR4⁺ T cells and associated TLR4-expression 14 days after burn injury. These data may represent a major mechanism for the increased functional T cell response observed late after burn injury.



IMMUNE ENHANCED DIET IN SEVERE TRAUMATIC BRAIN INJURY: A PROSPECTIVE, RANDOMIZED, DOUBLE BLIND TRIAL

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Presenter: Samir M. Fakhry, M.D.

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

Objective: Consensus recommendations for severe traumatic brain injury (TBI) include immune enhanced diet (IED) despite the lack of Class 1 data. The purpose of this prospective randomized double blind trial was to compare outcomes between an IED and an isocaloric, isonitrogenous control diet (CD) in patients with severe TBI. **Methods:** Patients admitted to an ICU at a Level 1 Trauma Center (3/02 -12/04) with severe TBI managed by protocol were randomly assigned to enteral support with IED or CD after informed consent. Feeding began within 72 hours of admission and continued for 14 days. Outcome parameters including septic morbidity, length of stay and mortality were collected. **Results:** 59 patients were entered into the study and 28 received IED. No significant differences in ISS, field GCS, highest ICP in the first 72 hours, total study days and total volume per kg of feed existed between groups. Mean age was greater in the IED group (42 vs 30 yrs, p<0.05). No significant difference in outcome parameters including length of stay, septic morbidity, number of days to infection or mortality existed between groups (Table 1). Regression analysis showed no significant benefit for IED compared to CD for any outcome variable.

Conclusions: This study was unable to demonstrate a significant advantage of IED over an isocaloric, isonitrogenous CD in patients with severe TBI. Consensus recommendations for the use of IED in severe TBI remain unsupported in the scientific literature.

Table 1

	IED	Control	p
Mortality (Death)	5	9	0.31
Infection (y)	24	23	0.27
Pneumonia (y)	18	20	0.99
Sepsis (y)	23	20	0.13
Antibiotics (y)	28	31	0.34
LOS (mean)	22.8 (± 12.4)	24.7 (± 16.7)	0.63
ICU (mean)	12.2 (± 4.3)	10.8 (± 4.7)	0.25
Vent Days (mean)	13.8 (± 4.5)	13.3 (± 7.2)	0.74
# Infections (mean)	2.3 (± 1.3)	2.4 (± 2.1)	0.77
# Pneumonia (mean)	0.8 (± 0.7)	1.1 (± 1)	0.16
# Sepsis (mean)	0.9 (± 0.5)	0.9 (± 1)	0.97
# Abx Course (mean)	3.2 (± 2.2)	3.6 (± 2)	0.48
Days to Feed (mean)	2.1 (± 0.9)	2 (± 0.8)	0.61
Days to Infection (mean)	7.4 (± 6.8)	4.8 (± 3.7)	0.48

B-HYDROXY-B-METHYLBUTYRATE IMPROVES NITROGEN BALANCE IN CRITICALLY INJURED ADULT TRAUMA PATIENTS

DA Kuhls MD, JA Rathmacher PhD, MD Musngi BS, D Frisch, PharmD, A Barber MD, AD MacIntyre DO JE Coates DO,TD Browder, P Eubanks JJ Fildes MD*

Presenter: Debra A. Kuhls, M.D.

Invited Discussant: Chris Cribari, M.D.

Background: Negative nitrogen balance and skeletal muscle loss are common in critically injured patients and may contribute to morbidity, mortality and resource utilization. An enteral combination of β -hydroxy- β -methylbutyrate (HMB), arginine (ARG), and glutamine (GLN) has been shown to restore muscle in cachectic AIDS and cancer patients. More recently HMB has been shown to attenuate cancer-induced muscle loss by decreasing muscle proteolysis. The purpose of this study was to determine if HMB or HMB/ARG/GLN would have a similar effect on critically injured trauma patients. We hypothesized that nitrogen balance would be improved and muscle proteolysis decreased with HMB and HMB/ARG/GLN supplementation.

Methods: 100 adult trauma patients with ISS >18 were enrolled in this prospective, randomized, blinded study. All patients received standard tube feeds and one of three iso nitrogenous supplements: HMB, HMB/ARG/GLN or placebo (PLAC) for 28 d. Urine, serum and clinical data were collected for 72 patients receiving at least 7 d of supplementation during the first 14 d of treatment. Urinary 3-methylhistidine (3-MH) was used as a proxy for muscle proteolysis.

Results: The three groups were similar in age, gender, mechanism and severity of injury, with the average ISS being 31.9. Utilizing covariant (ISS) repeated measure (d 1-14) mixed model (SAS) analysis, there was a significant treatment effect ($p=0.05$) on nitrogen balance (g/d). Change in nitrogen balance from the first 7d to the last 7 d was -1.1 for the HMB and -3.0 g/d HMB/ARG/GLN groups compared to -4.9 g/d for the PLAC group. . 3-MH excretion and 3 MH to creatinine ratios were lower initially in the PLAC group and remained lower throughout as compared to the HMB/ARG/GLN and HMB groups (Treatment Effect, $p=0.05$). **Conclusions:** These data suggest that supplementation with HMB alone may improve nitrogen in critically injured adult patients and that this effect is not due to lowered muscle protein turnover as originally hypothesized.

**PROTEIN OXIDATION IN SEVERELY INJURED TRAUMA PATIENTS:
FINDINGS IN A CONTEMPORARY MANAGEMENT SETTING**

Jason C. Roland MD, Gary L. Ecelbarger MS CNSD, Khashayar Vaziri MD, Linda Robinson MS MA RN, Anne Rizzo MD, Christopher P. Michetti MD, Hani Seoudi MD, Kevin M. Dwyer MD, Samir M. Fakhry MD*

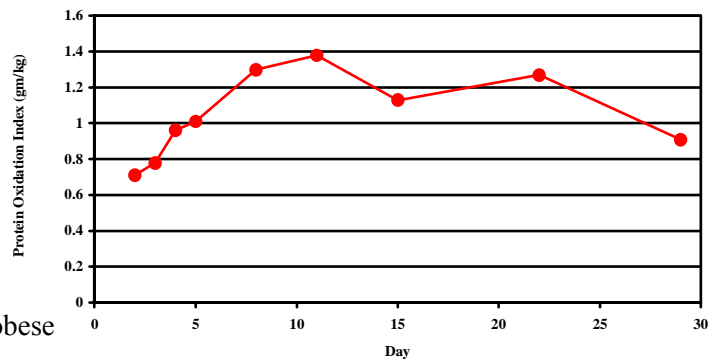
Presenter: Jason C. Roland, M.D.

Invited Discussant: Lorraine Tremblay, M.D.

Objectives: Critically injured patients were first shown to exhibit increased protein catabolism and urinary nitrogen loss more than 60 years ago with a characteristic “ebb” and “flow.” The purpose of this study was to quantify protein oxidation in severely injured patients to further define this response in a modern ICU setting. **Methods:** A prospective observational study of trauma patients admitted to the ICU at a Level I Trauma Center with an anticipated stay > 72 hrs was performed. 24-hr urinary urea nitrogen (UUN) measurements were obtained on hospital days 2, 3, 4, 5, 8, 11, 15, 22, and 29. Protein oxidation index (POI) was calculated as UUN X 6.25/kg actual weight. Patients with oral intake within 24 hrs of admission, liver or renal impairment, pregnancy, or age < 16 were excluded. **Results:** 95 patients were included in the study (72% male, mean age = 40, mean ISS = 28.6). 19% were obese with a body mass index (BMI) > 30 kg/m². POI exceeded baseline levels by day 2 and increased gradually, peaking at day 11

(median = 1.38 gm/kg). POI remained elevated throughout the study period (Fig. 1). ISS > 20 was associated with a greater peak POI of (1.34 vs 0.97 gm/kg, p<0.05). Peak POI of obese patients was not significantly different from non-obese patients.

Median Protein Oxidation Index



Conclusions: Trauma patients have already entered the flow phase of protein catabolism by the second post-injury day and remain in an elevated state for at least one month. Peak POI correlates with actual body weight in obese patients, and is influenced by severity of injury.

**INTESTINAL EPITHELIAL CELL-BACTERIAL INTERACTIONS SERVE AS
A PROXIMAL SIGNAL FOR ACTIVATION OF CIRCULATING
NEUTROPHILS**

Lawrence N Diebel, MD*, David M Liberati, MS, William J Brown, PhD, Clement A Diglio,
PhD

Presenter: Lawrence N. Diebel, M.D.

Invited Discussant: Jose Diaz, M.D.

Introduction: Mediators leave the postischemic gut via the lymph and activate circulating polymorphonuclear cells (PMNs) and cause organ injury. The gut contains a vast array of immunoinflammatory cells and luminal bacteria and other antigens. The initiating event which triggers PMN activation and remote organ injury following gut ischemia-reperfusion (I/R) insults is unknown and difficult to study *in vivo*. The purpose of this study was to assess the effect of IEC-bacteria coculture products from different culture conditions on the activation of naïve PMNs *in vitro*.

Methods: Caco2 cell monolayers established in a two-chamber cell culture system were exposed to either apical chamber *E. coli* C25 (EC) and/or hypoxia/reoxygenation (H/R). Caco2 cells under 21% O₂ conditions served as control. Naïve PMNs from normal human volunteers were challenged with basal chamber supernatants from the Caco2 preparations and percentage of CD11b expression, superoxide anion (O₂⁻) production, and elastase release quantitated.

Results

	Control	Caco2 H/R	Caco2 + EC	Caco2 H/R + EC
% CD11b	32.0 ± 2.3	37.7 ± 1.8	40.7 ± 1.2	125.3 ± 1.8*
O ₂ -	2.8 ± 0.4	3.1 ± 0.5	3.2 ± 0.7	8.2 ± 0.3*
Elastase	8.7 ± 0.6	9.0 ± 1.1	9.1 ± 0.4	10.4 ± 0.6

*p < 0.001 vs. other groups (n = 4 each)

Conclusion

Mediators produced from IEC-gut bacteria interactions during H/R activate naïve PMNs. These interactions may be the initial signal which triggers a systemic immunoinflammatory response and remote organ injury following I/R gut insults *in vivo*.

**ENDOTHELIN-1 AND cAMP INHIBITION ATTENUATE
ISCHEMIA/REPERFUSION INDUCED FLUID LEAK**

Rene M. Ramirez MD, Terry Chong MD, Gregory P. Victorino MD. Department of Surgery,
UCSF-East Bay
Sponsor: James M. Betts MD*

Presenter: René M. Ramirez, M.D.

Invited Discussant: John J. Ferrara, M.D.

Introduction: A consequence of ischemia-reperfusion (IR) is endothelial barrier dysfunction and the subsequent intravascular volume loss is a major clinical concern. We hypothesize that early IR induced fluid leak can be attenuated by inhibition of cAMP synthesis and perfusion with endothelin-1. The purposes of our study are to explore the impact of: (1) cAMP synthesis inhibition, (2) treatment with endothelin-1, and (3) endothelin-1 mediated cAMP changes on IR induced microvascular fluid leak.

Methods: A micro-occlusion technique was used to determine hydraulic permeability (L_p) in rat mesenteric venules. Ischemia was obtained in a 5% oxygen environment during prevention of flow. Resuming flow reperfused microvessels. L_p was measured after IR and also after treatment with (1) cAMP synthesis inhibitor (2',5' dideoxyadenosine, 10uM), (2) endothelin-1 (80pM), and (3) cAMP synthesis inhibition plus endothelin-1, (n=5 in each group; L_p represented as mean \pm SEM; units 10^{-7} cm/sec/cmH₂O.)

Results: IR resulted in a significant increase in L_p ($L_p=7.07\pm 0.20$) 7-fold above baseline (1.05 ± 0.31) ($p < 0.001$). Pretreatment with cAMP synthesis inhibitor significantly attenuated IR induced leak ($L_p = 3.92\pm 0.20$) ($p < 0.001$). Treatment with endothelin-1 after IR also decreased leak ($L_p = 5.38\pm 0.28$) ($p < 0.001$). Pretreatment with a cAMP inhibitor during IR plus treatment with endothelin-1 resulted in the most significant decrease in leak with nearly a 50% reduction ($L_p = 2.95\pm 0.12$) ($p < 0.001$).

Conclusion: The second messenger, cAMP, is a mediator of IR induced fluid leak. Inhibition of cAMP synthesis attenuates fluid leak due to IR injury. Endothelin-1 also attenuates leak in the setting of IR. When administered together their effects are additive which may indicate different intracellular signal transduction pathways and may allow a potential target for therapeutic interventions in the setting of IR injury.

PHYSIOLOGIC EXHAUSTION IS SIGNALLED BY REDUCED HEART RATE VARIABILITY & FAILURE OF THE AUTONOMIC NERVOUS SYSTEM: A STUDY OF 1000 TRAUMA PATIENTS

John A. Morris, Jr., M.D.* (1)

Patrick R. Norris, M.S. (1)

Asli Ozdas, Ph.D. (1)

Ioannis Tsamardinos, Ph.D. (2)

Lemuel R. Waitman, Ph.D. (2)

Vanderbilt University Medical Center

Department of Surgery (1)

Presenter: John A. Morris, Jr., M.D.

Invited Discussant: Robert J. Winchell, M.D.

OBJECTIVE(S): Measurements of a patient’s physiologic reserve (age, admission lactate [LAC_I], time to lactate normalization [LAC_T], transfusion requirements [uPRBC]) reflect robustness of response to surgical insult. We have previously shown that cardiac uncoupling (reduced heart rate variability, HRV) in the first 24 hours following injury correlates with mortality and autonomic nervous system failure. We hypothesize:

Deteriorating physiologic reserve (physiologic exhaustion) correlates with cardiac uncoupling. **METHODS:** 1053 trauma patients survived to normalize their plasma lactate levels within 72 hours. 136 experienced cardiac uncoupling (significant reduction in integer HRV > 17.6% of the first 24 hours). Risk for cardiac uncoupling was analyzed across categorical measurements of physiologic reserve, injury severity (ISS, closed head injury), and outcome using chi-squared test for trend of odds ratios and logistic regression.

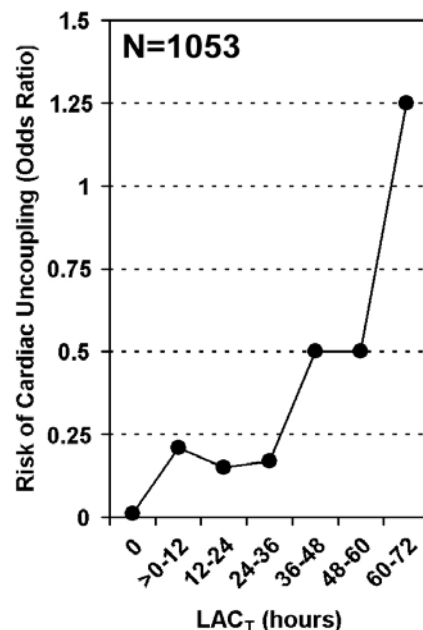
RESULTS: Deteriorating physiologic reserve increases risk of cardiac uncoupling (Figure, Table). Gender and ethnicity did not influence risk of uncoupling. **CONCLUSIONS:**

1. Heart rate variability is a new vital sign reflecting lactate normalization, transfusion requirement, and may be a surrogate for oxygen debt.
2. As physiologic exhaustion approaches, risk of cardiac uncoupling increases significantly.
3. We postulate: Declining physiologic reserve triggers a failure of autonomic control of multiple organ systems,

and cardiac uncoupling is the first example of this phenomenon.

	OR	95% CI
LAC _T *	1.53	1.30-1.78
LAC _I *	1.27	1.10-1.45
PRBC*	1.31	1.21-1.41
Age*	1.45	1.32-1.59
ISS*	1.52	1.24-1.86

*p < 0.001 for trend in odds ratios (OR); CI= Conf. interval



**TRAUMA SYSTEM DEVELOPMENT IN A THEATER OF WAR:
EXPERIENCES FROM OPERATION IRAQI FREEDOM**

Donald Jenkins, M.D. Wilford Hall Medical Center, Brian Eastridge, M.D., US Army Institute of Surgical Research, Henry Schiller, M.D., Mayo Clinic, Peter Rhee, M.D., Navy Trauma Training Center / USC, John Holcomb, M.D., US Army Institute of Surgical Research

Presenter: Donald Jenkins, M.D.

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

Introduction: Medical lessons learned from Vietnam and previous military conflicts led to the development of civilian trauma systems in the United States. Operation Iraqi Freedom represents the first protracted large scale armed conflict since the advent of civilian trauma systems in which to evaluate the paradigm in a battlefield environment. **Methods:** Collaborative efforts between the joint military forces of the United States initiated the development of a theater trauma system in May 2004. In collaboration with the Surgeons General of the US military, the USAISR and the Committee on Trauma, formal implementation of the system occurred in November 2004. A trauma surgeon (Trauma System Director) and a team of six trauma nurse coordinators were deployed to theater in order to address trauma system component issues. Demographic, mechanistic, physiologic, diagnostic, therapeutic, and outcome data were gathered using a Joint Theater Trauma Registry (JTTR) on 4700 injured patients. Interview and survey methods were utilized to evaluate logistic aspects of the system. **Results:** System implementation identified more than 30 systemic issues requiring policy development, research, education, evaluation of medical resource allocation and alterations in clinical care. Among the issues were transmission of casualties from point of injury to the most appropriate level of care, trauma clinical practice guidelines, standard forms, prophylactic antibiotic regimens, morbidity/mortality reporting, on-line medical evacuation regulation, creation of military trauma data registry and implementation of a performance improvement program. **Conclusions:** The implementation of a theater trauma system demonstrated numerous opportunities to improve the outcome of soldiers on the battlefield.

**EXPERIENCE OF THE US MARINE CORPS SURGICAL SHOCK TRAUMA
PLATOON WITH 304 OPERATIVE COMBAT CASUALTIES DURING A 6
MONTH PERIOD OF OPERATION IRAQI FREEDOM**

Lowell W. Chambers, MD. Department of General Surgery, Camp Pendleton Naval Hospital

Bruce L. Gillingham, MD. Department of Orthopedic Surgery, Naval Medical Center San Diego

DJ Green, MD. Dept. of General Surgery, Camp Pendleton Naval Hospital

Peter Rhee* MD, Division of Trauma and Critical Care USC/LAC

Presenter: Lowell W. Chambers, M.D.

Invited Discussant: Michael J. Sise, M.D.

Background: The Forward Resuscitative Surgical System (FRSS) is a small, mobile trauma surgical unit designed to support modern US Marine Corps combat operations. Use of the FRSS during the invasion phase of Operation Iraqi Freedom (OIF) was associated with good results but the relatively small numbers of casualties treated prevented definitive assessment of the forward surgery's efficacy. The experience of two co-located FRSS teams during a six month rotation of service in OIF is reviewed to further evaluate the usefulness of small unit, forward surgical intervention in management of combat trauma.

Methods: Between September 1, 2004 and February 25, 2005 two FRSS teams and a surgical shock trauma platoon were co-located in a task-oriented unit designated the Surgical Shock Trauma Platoon (SSTP). Data concerning patient care prior to and during their treatment at the SSTP was maintained prospectively. Follow-up was obtained by e-mail correspondence with surgeons caring for the patients at higher echelons while they were still hospitalized and by retrospective chart review.

Results: There were 594 combat casualties evaluated at the SSTP of which 475 (80%) presented with penetrating trauma from high velocity fragments or gunshots. 304 (51%) patients with 508 injury sites underwent operative intervention at the SSTP. The overall survival was 97% with 33 of 34 (97%) serious (ISS 15-24) and 16 of 21 (76%) severe (ISS > 24) trauma patients surviving to functional outcome. Despite receiving as many as 15 casualties simultaneously and 44 casualties within a single 24 hour period, at no point were SSTP resources overwhelmed.

Conclusions: Small task-oriented surgical units are capable of providing effective trauma surgical care to combat casualties. Further experience is needed to better delineate the balance between early, forward-based surgical intervention and more prolonged initial casualty evacuation to reach more robust surgical facilities.

Session V

Paper 33 8:30

OUTCOMES OF COMBAT CASUALTIES WITH HAND BURNS: DETECTING CLINICAL CHANGES BY MEASURING PHYSICAL IMPAIRMENT AND DISABILITY OVER TIME

TT Chapman, OTR; LC Cancio*; TL Hedman, MPT; SE Wolf, MD; JB Holcomb*, MD
U.S. Army Institute of Surgical Research

Presenter: Ted T. Chapman, M.D.

Invited Discussant: Carlos E. Donayre, M.D.

Purpose: To evaluate the outcome of hand burns over time by assessing the correlation between, and responsiveness to clinical change of, the American Medical Association (AMA) physical impairment measurements and Disabilities of the Arm, Shoulder and Hand (DASH) disability scores. **Methods:** Fifty-six U.S. military patients were treated and followed-up from March 2003 to February 2005, while recovering from hand burns sustained during operations in Iraq and Afghanistan. The mean age was 25 years and the mean burn size was 11.3%. Impairment (loss of strength, motion, sensation) and disability (loss of function) measurements were obtained at discharge and during subsequent follow-up visits for up to 18 months post burn. The AMA "Guides to the evaluation of permanent impairment, 5th ed.", was used to calculate impairment and the DASH questionnaire was used to measure disability. T and Spearman's tests were used to analyze the correlation between the AMA and DASH. **Results:** The AMA instrument was most sensitive to clinical change at 1-2 months post burn (standardized response means/effect size, 1.55/0.80) and during follow-up visits from 3-12 months (1.01/0.52). The DASH was highly responsive at 1-2 months post burn (1.06/1.02) and notably less responsive during follow-up visits from 3-12 months (0.36/0.33). A moderate correlation was found between the AMA and DASH (coefficient = 0.54, 95% CI = 0.38 - 0.71, $p < 0.0001$). Standardized response means and effect sizes indicated a large treatment effect during the initial months of recovery. The AMA and DASH measured clinical change throughout the recovery process with less sensitivity to change as impairment decreased and function improved. **Conclusion:** Detecting impairment and disability of the burned hand early in the recovery process allows for timely rehabilitation and surgical intervention to maximize functional outcomes. The AMA and DASH together provide a more comprehensive patient assessment to assist clinicians with determining a patients' level of independence and work limitations.

HEPATIC AND PULMONARY APOPTOSIS FOLLOWING HEMORRHAGIC SHOCK IN SWINE CAN BE REDUCED THROUGH MODIFICATIONS OF CONVENTIONAL RINGER'S SOLUTION

Eduardo C. Ayuste, MD, Elena Koustova, PhD, Huazhen Chen, MD, Peter Rhee, MD*, Naresh Ahuja, MD, and Hasan B. Alam, MD*
Uniformed Services University of the Health Sciences Bethesda, MD

Presenter: Eduardo C. Ayuste, M.D.

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

Cytotoxic properties of racemic (D-L isomers) lactated Ringer's solution detected *in-vitro* and in small animal experiments, have not been confirmed in large animal models. Our hypothesis was that in a clinically relevant large animal model of hemorrhage, resuscitation with racemic lactated Ringer's solution would induce cellular apoptosis, which can be attenuated by elimination of D-lactate. **METHODS:** 49 Yorkshire swine (40-58 kg) were subjected to uncontrolled (iliac vascular injuries) and controlled hemorrhage (total 40% blood volume). They were randomized to (n=7/group): 1) no hemorrhage (NH), 2) no resuscitation (NR), 3) 0.9% saline (NS), 4) racemic lactated Ringer's (DL-LR), 5) L-isomer lactated Ringer's (L-LR), 6) Ketone Ringer's (KR), 7) 6% hetastarch in 0.9% saline (Hespan). KR was identical to LR except for equimolar substitution of lactate with beta-hydroxybutyrate. Resuscitation was performed in 3 phases, simulating: 1) pre-hospital, 2) operative, 3) post-operative/recovery periods. Arterial blood gasses, circulating cytokines (TNF- α , IL-1, -6, -10), and markers of organ injury were serially measured. Metabolic activity of brain, liver, and muscle was measured with microdialysis. Four hours post-injury, organs were harvested for RT-PCR, Western blotting, ELISA, TUNEL assay, and immunohistochemistry. **RESULTS:** All resuscitation strategies restored blood pressure, but clearance of lactic acidosis was impeded following DL-LR resuscitation. Metabolic activity decreased during shock and improved with resuscitation (inter-group $p > 0.05$). Levels of cytokines in circulation were similar, but tissue levels of TNF in liver and lung increased 6- and 3-folds ($p < 0.05$) in NR group, whereas they were low in NS and KR groups ($p < 0.05$ vs. NR & DL-LR). DL-LR resuscitation increased hepatic and pulmonary apoptosis ($p < 0.05$), which was not seen after resuscitation with modified solutions. **CONCLUSIONS:** In a large animal model of hemorrhagic shock, resuscitation with conventional (racemic) LR solution increases apoptotic cell death in liver and lung. This can be attenuated by simple elimination of D-lactate from the Ringer's solution.

**GENES IN HEMORRHAGIC SHOCK: TREATMENT-TIME-ORGAN
CONTINUUM**

Elena Koustova, PhD, Huazhen Chen, MD, Hasan B. Alam, MD
Uniformed Services University of the Health Sciences, Bethesda, MD

Presenter: Elena Koustova, Ph.D.

Invited Discussant: Jeffrey D. Kerby, M.D., Ph.D.

Although transcriptional profiling is now days a familiar technique, its application to systematic studying of various biological phenomena is still limited due to the cost and effort involved. This research project's objective was to create a comprehensive summary of changes in gene expression following hemorrhagic shock (HS), reliant and impartial of multiple variables, such as resuscitation treatments, organ analyzed, and time after impact. Methods: Rat model of severe (50% total blood loss) HS was employed. HS was treated with 6 different resuscitation strategies (5-6 animals per treatment): 1) racemic lactated Ringer's (DL-LR); 2) L-lactated Ringer's (L-LR); 3) ketone Ringer's (KR); 4) pyruvate Ringer's (PR); 5) 6% Hetastarch (Hex); 6) 7.5% hypertonic saline (HTS). Non-resuscitated and non-hemorrhaged rats served as controls. Total RNA from liver, lung and spleen was isolated immediately (0 h) and 24h post resuscitation. Each organ, time point and treatment was profiled using individual cDNA array (1200 genes), to produce 248 separate micro-array data files. Statistical methods included analysis of means, unbalanced ANOVA and Sokal-Michener average linkage clustering. Results: Unresuscitated HS produced the highest number (56) of upregulated expressions in spleen and lungs. HEX and HTS affected mostly pulmonary genes (22 and 9). 14 genes changed in response to combination of all three factors: treatment, organ and time. 18 genes were identified as treatment-specific. 15 genes adjusted expression 24 h post treatment. The largest number of genes with altered expression (168) responded differently in all three organs. 30 gene clusters were pinpointed in our study: the largest cluster (543 genes) showed no change. 13 single-gene clusters showed unique responses to various resuscitation strategies.

Conclusions: We have reliably identified single genes and gene clusters that are affected by HS and are responsive to resuscitation. Gene expression in various organs is affected differentially by HS, which can be further modulated by the choice of resuscitation strategy.

AUDIENCE RESPONSE SYSTEM TECHNOLOGY IMPROVES ACCURACY AND RELIABILITY OF TRAUMA OUTCOME JUDGMENTS

David G. Jacobs MD*, Jennifer R. Sarafin RN, Toan Huynh MD*, William S. Miles, MD, Ronald F. Sing, DO*, Michael H. Thomason MD*. Carolinas Medical Center

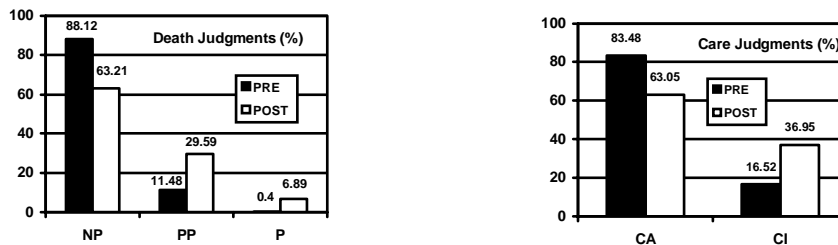
Presenter: David G. Jacobs, M.D.

Invited Discussant: Michael D. Pasquale, M.D.

Background: Peer-review judgments are a necessary and critical component of trauma process improvement (PI), but if rendered in a non-anonymous fashion, may be influenced by peer pressure and the tendency to vote with the majority. We propose that incorporation of Audience Response System (ARS) technology into trauma PI will protect reviewer anonymity, and result in more divergent and more critical outcome assessments.

Methods: We retrospectively compared 29 months of non-anonymous physician PI judgments (PRE group) to 28 months of anonymous PI judgments obtained with a keypad-based ARS (POST group). Trauma deaths were judged as non-preventable (NP), potentially preventable (PP), or preventable (P). Overall trauma care was judged as appropriate (CA) or inappropriate (CI). Statistical methods included the chi-square test for nominal data, and the Wilcoxon rank sum test for data measured on the interval scale.

Results: 740 PRE death judgments were compared with 749 POST death judgments, and 1102 PRE care judgments were compared with 1107 POST care judgments. Use of the ARS resulted in a significant 28% reduction in deaths judged NP, and significant increases in deaths judged PP and P [p<0.0001]. Similarly, the ARS resulted in a significant 24% decrease in care judged CA, and a significant increase in care judged CI. [p<0.0001].



Conclusions: Physician-derived outcome judgments obtained anonymously were significantly more divergent and less positive than those obtained non-anonymously. Anonymously derived outcome judgments may provide a better opportunity to identify adverse outcomes, and thereby potentially improve trauma PI.

PREDICTING QUALITY OF LIFE SIX MONTHS AFTER TRAUMATIC INJURY

James M. Kiely, MD. Medical College of Wisconsin.
 Karen J. Brasel, MD, MPH. Medical College of Wisconsin.
 Clare E. Guse, MS. Medical College of Wisconsin.
 Kevin L. Weidner, MS. Medical College of Wisconsin.
 John A. Weigelt, MD. Medical College of Wisconsin.

Presenter: James M. Kiely, M.D.

Invited Discussant: Ellen MacKenzie, M.D.

Background: Factors that predict Quality of Life (QoL) after traumatic injury are incompletely understood. The aim of this study was to examine correlates of QoL measured by the Short Form-36 (SF-36) one and six months post-injury.

Methods: Adults with non-neurologic blunt injury were prospectively enrolled. Demographic, injury, and socioeconomic data were collected. Patients were assessed with functional and psychologic measures. 185 patients had 1-month data and 110 had 6-month data available. Scores were compared and also to population norms using t-tests. Linear regression was used to identify correlates of the physical and mental component scores (PCS & MCS) of the SF-36.

Results: PCS scores improved significantly over time while MCS scores did not improve. Both remained significantly below population norms (see table). Functional independence measure (FIM) was correlated with PCS at both time points. Length of stay was inversely correlated with PCS at 6 months. Post traumatic stress disorder (PTSD), depression, female gender, and poor social support were correlated with lower MCS. ISS and orthopedic injury were not correlated with PCS or MCS.

	One month	Six months	Norms
SF-36 PCS	31.8 ± 0.7*	41.4 ± 1.0	50.0 ± 0.2 [†]
SF-36 MCS	47.4 ± 0.9	47.7 ± 1.1	50.0 ± 0.2 [†]

*p<0.001 vs PCS six months, [†]p<0.05 vs PCS, MCS one and six months

Conclusions: Overall physical and mental QoL remains significantly below population norms 6 months after traumatic injury. It is possible to identify patients at risk for diminished QoL early in their recovery by screening for functional status, PTSD, social support, and depression. Interventions to address these areas should be further studied with respect to their impact on long-term QoL.

EVALUATION OF FUNCTIONAL OUTCOME AND QUALITY OF LIFE ONE YEAR AFTER PEDIATRIC TRAUMA

Craig L. Weinstein MD; Andrea L Winthrop MD; Linda Stahovic MSW; Justin Paulson BS;
Evelyn M Kuhn PhD; Karen J Brasel MD MPH*

Divisions of Pediatric Surgery and Trauma/Critical Care, Department of Surgery, Medical College of Wisconsin; and National Outcomes Center, Children's Hospital and Health System, Milwaukee, Wisconsin

Presenter: Craig L. Weinstein, M.D.

Invited Discussant: Timothy Emhoff, M.D.

Purpose: Evaluation one year after pediatric trauma to identify the time dependent nature of functional outcome and quality of life (QOL) and potential markers of suboptimal recovery. **Methods:** We studied children aged 1-18 after blunt trauma with ISS ≥ 9 and GCS > 12 . Children were evaluated at hospital discharge, 1, 6, and 12 months utilizing Child Health Questionnaire (CHQ- PF28; ≥ 5 years), Infant/Toddler Quality of Life (CHQ-IT; < 5 years), Wee Functional Independence Measure (WeeFIM) and Impact on Family Scale (IOF). Significance was set at $p < 0.05$ for paired t-test analysis examining change in scores and z-tests for comparison of scores to normative data. Regression analysis identified variables associated with CHQ physical and psychosocial summary scores. **Results:** There were 110 children who completed 1 month evaluation, 73 at 6 months, and 51 completing 12 month evaluations. Although there was significant improvement in all scores between baseline, 1 month, and 6 months post injury, only the WeeFIM mobility score and the economic subscale of the IOF continued to improve at 12 months. Overall IOF score at 1 month was associated with CHQ physical score at 6 and 12 months ($p = 0.039$ and 0.027 , respectively). The table shows means \pm standard deviations.

	6 months	12 months	Normal Population
CHQ psychosocial	50.5 \pm 11.1	49.0 \pm 10.5	51.1 \pm 9.6
CHQ physical*	44.4 \pm 14.6*	45.2 \pm 15.1*	53.2 \pm 9.5
CHQ-IT physical	97.3 \pm 5.1	98.3 \pm 2.8	--
CHQ-IT behavior	73.5 \pm 22.7	80.4 \pm 17.4	--
CHQ-IT change in health	63.3 \pm 28.1	83.3 \pm 30.3	--
WeeFIM total	6.8 \pm 0.6**	6.9 \pm 0.3^	7.0

Comparisons to normative data: * $p < 0.01$ for comparison at 6 and 12 months; ** $p < 0.05$ for comparison at 6 months; ^ $p = \text{NS}$ (.093) for comparison at 12 months.

Conclusions: Most gains in QOL are achieved by 6 months post injury. At 12 months the CHQ physical score is still significantly below norm. Impact on Family score at one month appears to be a marker associated with QOL at 1 year.

ARE SURGICAL RESIDENTS COMPAREABLE WITH NIGHT HAWK RADIOLOGIST IN INTERPRETATION OF TRAUMA FILMS ?

A Guo MD,HRH
N Ahmed MD FACS,HRH

Presenter: A. Guo, M.D., HRH

Invited Discussant: Lynette A. Scherer, M.D.

Objective: To determine if senior surgical residents can independently and accurately interpret the trauma image studies in the absence of radiologists.

Methods: Five senior surgical residents (PGY-4 and 5) were included in this prospective study. They were requested, when on call for trauma, to read trauma images, and their interpretations were collected and later compared with the official reports by night hawk radiologists.

Results: Over a period of 2 months, a total of 173 images (Table) on 49 trauma patients admitted to a Level II trauma center were read by one of the five senior surgical residents, and later by a night hawk radiologist. Mechanism of injuries includes MVA (n=23), GSW (n=7), SW (n=4), fall (n=4), and assault (n=11). Our preliminary data shows the residents identified 51 injuries, compared to 52 injuries identified by the radiologists, from 173 image studies. The resident missed 2 injuries, while the radiologists missed one (Table).

Conclusions: Senior surgical residents can independently and accurately interpret the trauma image studies in ED during off-hours and make decisions about management of injuries based on their own interpretations of image studies. Hence, the need for reports from night hawk radiologists is superfluous, and a waste of resource

<u>X ray</u>	Total read	Injuries identified*	<u>CT</u>	Total read	Injuries identified	<u>Others</u>	Total read	Injuries identified
chest	38	6 (6)	head	32	10 (11)	urethrogram	1	0 (0)
C/S	24	1 (1)	C/S	13	2 (2)	U/S scrotum	1	0 (0)
pelvis	19	2 (2)	A/P	13	5 (6)			
extremity	4	2 (2)	chest	8	7 (6)			
KUB	7	2 (2)	face	10	12 (12)			
TLS	2	1 (1)	hip	1	1 (1)			

*numbers without parenthesis: injuries positively identified by residents
numbers with parenthesis: injuries positively identified by radiologists

MOLECULAR ANALYSIS OF INFLAMMATORY MARKERS IN TRAUMA PATIENTS AT RISK OF POST-INJURY COMPLICATIONS

Christine Toevs, MD James Hamilton, BS, Lee Y. Tee, BS, Marjolyn Brock, RHIA, D. Olga McDaniel, PhD., University of Mississippi Medical Center
(Sponsor Greg Timberlake*, MD)

Presenter: Christine Toevs, M.D.

Invited Discussant: Brian Harbrecht, M.D.

Background: Severe trauma injury often leads to the development of sepsis and organ failure. A challenge for appropriate treatment of sepsis is identification of the patients who are at increased risk for sepsis. Clinical findings support the fact that despite comparable risk factors, post trauma sepsis and organ failure develops in some patients but not in others. Hypothesis: In clinical setting, interindividual genetic differences associated with host immune responses appear to be a major contributing factor to the development of trauma induced infection and subsequent organ failure in patients. Methods: All blunt and penetrating trauma with ISS >15 were included in this study. Thirty eight patients, 17 African American and 21 Caucasian were studied. Peripheral blood mononuclear cells (PBMCs) were used for genotype and gene expression analysis. Genotypes of cytokines including IL-6, TNF-*, IL-10, IL-18, IFN-* and the genes for TLR-2 and TLR-4 were studied. Genotypes were detected by sequence specific primers and PCR. Results: A majority of patients (63%) have developed sepsis. However, 9 out of 10 African American male (90%) developed sepsis as compared with 53% Caucasian male; 75% Caucasian female and 43% African American females. In terms of cytokine genotypes, the G/C (-174G variant) high producer genotype was predominantly present in African American patients. In Caucasian patients, 83.3% of septic patients and 44.4% of aseptic patients carried the IL-6 high producer genotype ($p < 0.05$, Relative Risk: 1.9). The polymorphism is known to affect on transcription rates. The IL-6 mRNA transcript rate was 50% greater in African American septic patients as compared with aseptic patients. The Arg 753Gln TLR-2 polymorphism was found in 1 out of 12 (8.3%) Caucasian and 3 out of 11 (27.3%) African American septic patients. Notably, the TLR-2 mutation was found in 58.5% of Caucasian control as compared with 21% of African American controls, $p < 0.0001$. This result suggests that the TLR-2 mutation is a greater risk factor for development of sepsis in African American patients after infection with bacteria.

**NEUTROPHIL ELASTASE INHIBITOR, SIVELESTAT ATTENUATE
LEUKOCYTE DEFORMABILITY IN ACUTE LUNG INJURY.**

Yoshiaki Inoue, MD, Isao Ukai, MD, Youji Ogura, MD, PhD, Hiroshi Tanaka, MD, PhD,
Takeshi Shimazu, MD, PhD, and Hisashi Sugimoto, MD, PhD.

Presenter: Yoshiaki Inoue, M.D.

Invited Discussant: Jan K. Horn, M.D.

Objective: The purpose of this study is to evaluate the neutrophil elastase (NE), neutrophil deformability, and the effects of a NE inhibitor, Sivelestat in acute lung injury (ALI).

Subjective: Twenty-three patients with systemic inflammatory response syndrome (SIRS) were divided into 2 groups; 13 SIRS patients with ALI (ALI group), and 10 SIRS patients without ALI (SIRS group). **Methods-Study 1:** Leukocyte count (WBC), NE activity, and PaO₂/FiO₂ ratio (P/F ratio) were measured. Neutrophil deformability was observed in a microchannel array etched on a single-crystal silicon tip, which simulates the microvasculature. The number of microchannels obstructed (NOM) by stiffened neutrophils was counted. Transit time (TT), that is, the time taken for 100μL of whole blood to pass through the microchannel, was determined. **Study 2:** We administrated Sivelestat (4.8mg/day) during 5 days for 8 of 13 patients with ALI. The same parameters as study 1 and leukocyte actin contents were measured before and after Sivelestat. **Results-Study 1:** In the ALI group, NE activity, TT, and NOM were significantly higher than those in the SIRS group (p<0.05).

Group	N	age	WBC	P/F ratio	NE activity (ng/ml)	TT (sec/10mL)	NOM
SIRS	10	55±20	10040±8700	315±28	130±113	15±14	8±4
ALI	13	64±13	10800±4900	190±51*	235±230*	60±51*	14±21*

Study 2: NE activity, TT, and NOM were significantly lower than those of basal data, and P/F ratio was recovered after 5 days of Sivelestat administration (*p<0.05, **p<0.01).

	NE activity (ng/ml)	Leukocyte actin contents (meanfluorescence /cell)	TT (sec/10m L)	NOM	P/F ratio
Pre	206±169	125±34	59±36	14±2	185±51
Post	50±16*	108±31	19±12*	9±3**	281±47**

Conclusion: NE activity and neutrophil deformability were significantly deteriorated in patients with ALI. Sivelestat attenuated lung oxygenation in patients with ALI by the reduction of NE activity and neutrophil stiffness.

NOREPINEPHRINE (NE) DOES NOT MODULATE WOUND MACROPHAGE PHAGOCYTOSIS.

Ankush Gosain, M.D.
Stephen B. Jones, Ph.D.
Ravi Shankar, Ph.D.
Richard L. Gamelli, M.D.*
Luisa A. DiPietro, D.D.S., Ph.D.

Burn and Shock Trauma Institute

Presenter: Ankush Gosain, M.D.

Invited Discussant: Lewis J. Kaplan, M.D.

Introduction: Patients with sepsis have elevated circulating levels of catecholamines, which are further increased by the clinical use of vasopressors. Multiple lines of investigation have demonstrated immune cell modulation by catecholamines. Despite this, the role of NE from sympathetic efferents in cutaneous wound healing is poorly understood. There is evidence that NE modulates macrophage chemotaxis *in vitro* and we have recently demonstrated that macrophage recruitment to wounds is delayed in the absence of NE. We hypothesized that NE may additionally modulate wound macrophage phagocytic function.

Methods: NE-depleted (NED) mice (8-9 week female Balb/c) were generated by chemical axotomy with 6-hydroxydopamine and compared to NE-intact (NEI) mice. Wound macrophages were isolated from subcutaneously implanted polyvinyl alcohol sponges at 72 and 120 hours post-injury and *in vitro* phagocytosis of latex beads in response to LPS stimulation was assessed.

Results: NED and NEI macrophages did not differ in phagocytic index versus time (NEI 4.3±1.3% vs. NED 3.5±2.1% at 72 hrs; NEI 8.8±3.4% vs. NED 6.0±1.6% at 120 hrs; p=NS).

Conclusions: NE does not appear to modulate macrophage phagocytic function in this model. Taken together, unchanged phagocytic function combined with the delay in macrophage infiltration suggest that the lack of NE from peripheral nerves leads to a globally impaired ability to clear skin wound debris.

Supported by NIH T32-GM08750, GM50875 and GM55238.

GUT- LYMPH HYPOTHESIS OF ACUTE SIRS/MODS: VALIDATING STUDIES IN A PORCINE MODEL.

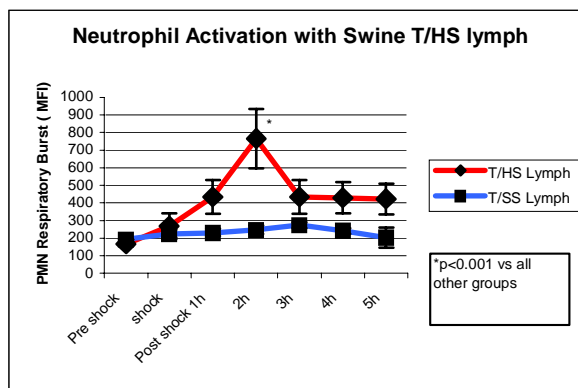
Maheswari Senthil M.D., Margaret Brown, Da-Zhong Xu M.D. Ph.D., Qi Lu M.D., Elenora Feketeova M.D., Tamara Berezina M.D., Sergey Zaets M.D., Edwin A. Deitch M.D.*
Department of Surgery, University of Medicine and Dentistry of New Jersey, Newark.

Presenter: Maheswari Senthil, M.D.

Invited Discussant: Paul E. Bankey, M.D., Ph.D.

Introduction: Trauma- Hemorrhagic shock (T/HS) mesenteric lymph from rats possess multiple biological properties and appears to cause organ injury via the activation of neutrophils and endothelial cell injury. And to further test the potential clinical relevance of this rodent studies, we utilized a swine T/HS model, since the pig and human intestines are similar. **Methods:** Male pigs were subjected to T/HS and cannulation of cisterna chyli. Hemorrhagic shock (MAP 40mmhg) was performed by withdrawing blood until the base deficit reached -5. Animals were then resuscitated in two stages to mimic the prehospital and hospital phase of resuscitation. Mesenteric lymph was collected hourly throughout the experiment and its biological activity was tested on neutrophils (respiratory burst) and endothelial cells (monolayer permeability and cytotoxicity). **Results:** T/HS lymph but not Trauma- sham shock lymph (T/SS) resulted in increased neutrophil activation which peaked at 2h post-shock (Figure). Likewise T/HS lymph collected at all time points upto 5h post shock (not T/SS lymph) significantly increased endothelial cell permeability by 2 fold or greater ($p<0.05$). T/HS lymph produced during and first 2h post shock, but not later was cytotoxic for endothelila cells (viability 70% of that of preshock) ($p<0.05$).

Conclusion: This large animal model



validates rodent studies showing that the shock –injured gut releases biologically active factors in mesenteric lymph resulting in neutrophil-endothelial cell activation injury. These results also indicate that the time course of the release of these gut derived factors varies to some extent based on the property tested. And suggests that any therapeutic intervention directed at neutralizing the toxicity of T/HS lymph must begin during initial resuscitation.

**HSPTX IS A BETTER RESUSCITATION FLUID THAN LR: EFFECTS ON
END-ORGAN INJURY.**

Raul Coimbra Md, PhD*, Rafael Porcides MD, William Loomis BS, Heidi Melbostad BS, Rohan Lall MD, David B. Hoyt MD, Paul Wolf MD.

Presenter: Raul Coimbra, M.D., Ph.D.

Invited Discussant: David Burris, M.D.

Conventional fluid resuscitation with lactated Ringers (LR) activates neutrophils and causes end-organ damage. We have shown that HSPTX, a combination of small volume hypertonic saline (HS) and pentoxifylline (PTX), a phosphodiesterase-inhibitor, downregulates in vitro neutrophil activation and pro-inflammatory mediator synthesis. We hypothesized that HSPTX decreases end-organ injury when compared to LR in an animal model of hemorrhagic shock

Sprague-Dawley rats were bled to a mean arterial pressure of 35 mmHg for one hour. Animals were divided into 2 groups: Group 1: HSPTX (7.5% NaCl 4 ml/kg + PTX 25 mg/kg; n=10), Group 2: LR (total volume matched to sodium load of group 1; n=10). Animals received shed blood. A Sham group (no shock, no resuscitation) was also used. Blood pressure was monitored until the end of resuscitation. Animals were sacrificed at 24h after resuscitation. Bronchoalveolar lavage fluid (BAL) was obtained for cellularity. Lung and intestinal injury at 24 h were evaluated by histopathology and immune staining. Organ damage was graded by a pathologist and a score was created (0=no injury; 3= severe).

There were no differences in mean arterial pressure between groups. At 24 hours, HSPTX-resuscitated animals (lung injury score= 1.0 ± 0.4) had markedly decreased acute lung injury compared to LR-treated animals (2.5 ± 0.3) ($p < 0.001$). BAL leukocyte count was decreased by 30% in HSPTX animals. LR resuscitation led to a 2-fold increase in lung neutrophil infiltration whereas in HSPTX-treated animals, the number of MPO+ cells was similar to Sham animals. Intestinal injury was markedly attenuated by HSPTX (1.1 ± 0.3) compared to LR animals (2.6 ± 0.4) ($p < 0.001$).

HSPTX, a small volume resuscitation strategy with marked immunomodulatory potential led to a marked decrease in end-organ damage. HSPTX is an attractive alternative to LR in hemorrhagic shock resuscitation.

CONVENTIONAL DOSE HYPERTONIC SALINE PROVIDES OPTIMAL IMMUNOMODULATION

Ernest A Gonzalez MD, Rosemary A. Kozar MD,PhD*, James W. Suliburk MD, David W. Mercer MD*, Frederick A. Moore*, University of Texas Health Science Center at Houston

Presenter: Ernest A. Gonzalez, M.D.

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

Introduction: Hypertonic saline resuscitation (HSR) prevents neutrophil mediated injury after shock. The optimal dose is not known, but appears due to osmotic stress. We hypothesized that a dose dependent effect exists related to increasing tonicity. Using our superior mesenteric artery occlusion model (SMAO), we compared the conventional (empirically derived) resuscitation dose (4ml/kg 7.5% HS) to increasing tonicity with equal volume or equal salt load boluses.

Methods: Rats were assigned to one of three groups. Controls (Sham/No Bolus, Sham/4ml/kg 7.5% HS, SMAO/No Bolus), SMAO/equal volume (4ml/kg 0.9% NS, 4ml/kg 2.5% HS, 4ml/kg 5% HS, 4ml/kg 7.5% HS and 4ml/kg 10% HS) or SMAO/equal sodium (33ml/kg 0.9% NS, 12ml/kg 2.5% HS, 6ml/kg 5% HS, 4ml/kg 7.5% HS and 3ml/kg 10% HS). All animals underwent internal jugular line placement and midline celiotomy. SMAO clamps were placed in the assigned groups for 60 minutes and boluses were given 5 minutes prior to clamp removal. Animals were sacrificed at 6 hours reperfusion. Ileum was harvested for analysis of myeloperoxidase (MPO) protein expression as an index of neutrophil mediated injury.

Results: SMAO/No Bolus doubles MPO levels compared to sham. Equal volume and equal sodium boluses decrease MPO levels with increasing tonicity at 7.5% in a dose dependent fashion, with the best effect at 7.5%.

Controls		Equal Volume		Equal Sodium	
Bolus	MPO (ug/dl)	Bolus	MPO (ug/dl)	Bolus	MPO (ug/dl)
Sham/No Bolus	2.33 ± 0.29 a	4ml/kg 0.9% NS	4.40 ± 0.48 c	33ml/kg 0.9% NS	4.99 ± 0.61 c
Sham/7.5% HS	2.67 ± 0.42 a	4ml/kg 2.5% HS	5.52 ± 0.67 c	12ml/kg 2.5% HS	5.96 ± 0.53 c
SMAO/No Bolus	4.92 ± 0.29 b	4ml/kg 5.0% HS	3.56 ± 0.34 b	6ml/kg 5.0% HS	4.10 ± 0.51 b
		4ml/kg 7.5% HS	2.89 ± 0.44 a	4ml/kg 7.5% HS	2.89 ± 0.44 a
		4ml/kg 10.0% HS	3.20 ± 0.30 b	3ml/kg 10.0% HS	3.49 ± 0.31 b

Means with different letters are significantly different ($p < 0.05$) within each group.

Conclusion: The protective effect of HS is related to increased tonicity (i.e. osmotic stress). The conventional resuscitation dose of HS provides optimal Immunomodulation.

LOW VOLUME HYPERTONIC SALINE ABROGATES MESENTERIC ISCHEMIA/REPERFUSION INDUCED REMOTE ORGAN INJURY

Ernest A. Gonzalez MD, Rosemary A. Kozar MD, PhD*, James W. Suliburk MD, David W. Mercer MD*, Frederick A. Moore MD*
 University of Texas Health Science Center at Houston

Presenter: Frederick A. Moore, M.D.

Invited Discussant: Susan I. Brundage, M.D., M.P.H.

Introduction: Low volume hypertonic saline (LVHS) resuscitation (Res) prevents shock induced multiple organ failure (MOF). Multiple mechanisms have been proposed, but recent studies suggest that LVHS effects on mesenteric ischemia/reperfusion (I/R) are pivotal. We have shown that LVHS protects the gut in isolated mesenteric I/R caused by superior mesenteric artery occlusion (SMAO) and hypothesized that LVHS would have similar beneficial effects in the liver and lung after SMAO compared to high volume normal saline (HVNS).

Methods: Rats were assigned to Sham/No Res, SMAO/No Res, SMAO/HVNS (33ml/kg 0.9% NS, equal salt load) or SMAO/LVHS (4ml/kg 7.5% HS). All animals underwent internal jugular line placement and midline celiotomy. SMAO clamps were placed in the assigned groups for 60 minutes and Res was given 5 minutes prior to clamp removal. Animals were sacrificed at 6 hours of reperfusion. Serum ALT and AST were measured as an index of liver injury and lung was harvested for analysis of myeloperoxidase (MPO) protein expression as an

index of lung injury. Data are reported as mean ± SEM (n = 5/group; ANOVA).

Model	ALT (U/L)	AST (U/L)	MPO (ng/dl)
Sham/No Res	40.98 ± 5.18 a	173.37 ± 20.56 a	5.18 ± 0.38 a
SMAO/No Res	86.08 ± 7.23 b	289.20 ± 51.37 b	6.53 ± 0.36 b
SMAO/HVNS	84.39 ± 11.23 b	231.64 ± 36.85 c	6.23 ± 0.28 b
SMAO/LVHS	61.74 ± 3.48 a	162.65 ± 14.21 a	5.05 ± 0.52 a

Means with different letters are significantly different ($p < 0.05$)

Results: SMAO/No Res significantly increased serum ALT, AST and lung MPO. HVNS Res had little effect on ALT, AST or MPO levels, but LVHS Res significantly decreased ALT, AST and lung MPO.

Conclusion: High volume NS had little effect on SMAO induced remote organ injury, while low volume HS Res was quite protective. This supports the growing evidence that HS protection in shock induced MOF may be due to its gut protective effects.

CONTINUOUS MUSCLE TISSUE OXYGEN MONITORING AS A GUIDE FOR RESUSCITATION OF CRITICALLY INJURED PATIENTS: A PROSPECTIVE OBSERVATIONAL STUDY

DG Ikossi, MD, D Morabito, RN, MPH, CL Stewart, BA, GT Manley, MD, PhD, MM Knudson, MD, FACS*
 San Francisco General Hospital, University of California, San Francisco
 San Francisco, CA

Presenter: Danagra G. Ikossi, M.D.

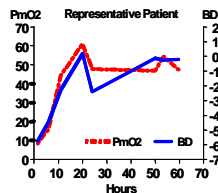
Invited Discussant: Stephen M. Cohn, M.D.

Background: Despite normalization of vital signs, critically injured patients may have occult hypoperfusion that sets the stage for sepsis, MODS, and death. In this pilot study, we evaluated the ability of 2 continuous measures of peripheral tissue oxygenation to detect hypoperfusion: Licox polarographic tissue oxygen monitor (PmO₂) and InSpectra near infrared spectrometer (StO₂).

Objectives: We hypothesized that deltoid muscle tissue oxygen monitoring could be used to guide resuscitation. This study was designed to examine 1) the range of PmO₂ and StO₂ values during resuscitation; 2) the relationship between PmO₂, StO₂, and standard physiologic parameters (MAP, PaO₂, PaO₂/FiO₂, BD); 3) the correlation between PmO₂ and StO₂. **Methods:** In this prospective observational study, on admission to the ICU, PmO₂ probes were inserted into the deltoid muscle of critically injured intubated patients, under ultrasound guidance. StO₂ monitors were placed proximal to the PmO₂ probes. PmO₂, StO₂, and standard physiologic data were collected continuously using a multimodal bioinformatics system. *Resuscitated* was defined as MAP ≥ 70 mmHg, BD ≥ -2, PaO₂ ≥ 80, FiO₂ ≥ 41%; *Under resuscitated*: BD < -6, PaO₂ < 80. **Results:** Data from 19 patients were analyzed.

	PmO ₂	StO ₂	PaO ₂	FiO ₂	BD	MAP
Resuscitated	39 ± 9	55 ± 19	109 ± 27	39 ± 2	0.2 ± 1.9	93 ± 13
Under resuscitated	28 ± 12	49 ± 36	127 ± 37	53 ± 19	-8.1 ± .8	94 ± 15

PmO₂ increased significantly when



BD resolved ($p < 0.001$), however, StO₂ did not ($p = 0.48$) (Table). As seen in Figure of a representative patient, PmO₂ trends with BD. Despite patient heterogeneity, there was a weak but significant correlation between BD and PmO₂ across patients, $r = 0.36$, $p < 0.001$. PmO₂ increased with increases in PaO₂ and closely followed PF ratio with the onset of lung dysfunction.

StO₂ and MAP did not consistently trend with PmO₂. StO₂ had great variability within and between patients and no clear association with other physiologic variables. **Conclusions:** PmO₂ increases as BD resolves and is a potential continuous guide for resuscitation in the ICU. Because of the variability of StO₂ in this setting we were unable to establish clear relationships with standard physiologic parameters. Further investigation of both technologies is indicated.

**TRAUMA CENTER BRIEF INTERVENTIONS FOR ALCOHOL DISORDERS
DECREASE INTOXICATED DRIVING**

CR Schermer*+ MD MPH, TB Moyers@ PhD, WR Miller@ PhD and LA Bloomfield+ MSW
+Department of Surgery University of New Mexico
@Center on Alcoholism, Substance Abuse and Addictions, University of New Mexico

Presenter: Carol R. Schermer, M.D., MPH

Invited Discussant: Larry M. Gentilello, M.D.

Background: For trauma centers to invest in brief interventions (BI) for alcohol disorders, an important outcome would be one that is relevant to trauma surgeons. There has been no prior report of BI after injury reducing DUI arrests. The hypothesis of this study was that injured patients receiving BI would have a lower risk of DUI arrest in the three years following discharge than those receiving standard care (SC).

Methods: This prospective randomized clinical trial randomly allocated patients involved in motor vehicle collisions to receive SC or a BI regarding alcohol use. The primary outcome measure was DUI arrest within 3 years of hospital discharge. Subjects were followed for three years after study participation. DUI arrests were documented by matching demographic information to state traffic safety data.

Results: After randomization (N=126) BI and SC groups were similar in age, prior DUI arrests, and alcohol screening score. BI sessions lasted an average of 30 minutes and were performed by either a social worker or a trauma surgeon. Approximately one in 6 subjects (n=21, 16.7%) had a DUI arrest within 3 years of hospital discharge. More than one in five (n=14/64, 21.9%) patients in the SC group had an arrest for DUI in the three years following hospital discharge compared to only 7/62 (11.3%) patients who received the BI. Multivariate analysis demonstrated that SC was the biggest predictor of recurrent DUI arrest (odds ratio [OR] = 2.9, CI 0.98-8.92). Screening score (OR= 1.1, CI 1.00-1.12) was also a predictor of DUI arrest after discharge but prior number of DUIs (OR = 1.3, CI 0.14-1.25) and age (OR 0.96, CI 0.91-1.00) were not clearly also associated with DUI arrest post hospitalization. The absolute risk reduction implies that only 9 patients would need to receive a BI to prevent one DUI arrest.

Conclusion: Patients who receive BI during a trauma center admission are less likely to be arrested for DUI in the 3-years following discharge. Trauma centers should have mechanisms in place to provide BI to hazardous and harmful drinkers.

REGIONAL DIFFERENCES IN OUTCOMES FOR HOSPITALIZED INJURED PATIENTS IN THE UNITED STATES

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Presenter: Richard Mullins, M.D.

Invited Discussant: Robert A. Maxwell, M.D.

Purpose: While the numbers of statewide and local trauma systems have increased systems' effectiveness remains controversial. Investigators need outcome standards to identify best practices. Our goal was to determine using a population-based data set if outcome and processes of care for hospitalized injured patients are uniform in the US.

Methods: Patients with a primary discharge diagnosis of injury (ICD-9 800 to 959) were identified in the HCUP/Nationwide Inpatient Sample for the years 1995-2000 and used to estimate the annual number of hospitalized injured patients in the Northeast (NE), South (S), Midwest (MW) and West (W) regions of the US. Injury severity was quantified using ICD-9 based survival risk ratios (ICISS: range 0 to 1 = highest survival). Rates were calculated as the average annual incidence of events over the 6 years for hospitalized patients per million person years in the region (estimated from census data) normalized by age and gender to 2000 census data. Outcomes measured were: 1. hospitalization rate 2. potentially unnecessary care (PUC) rate, defined as ICISS \geq 0.99, no procedures and discharged to home 3. death rate and 4. potentially ineffective care (PIC) rate defined as \geq 28 days of hospitalization ending in death. Risk-adjusted odds were calculated using ICISS, age, gender, co-morbidities, mechanism of injury and hospital characteristics.

Results:

Region	Hosp Rate	PUC Rate	Death Rate	Odds of Death (95% CI)	PIC Rate	Odds of PIC (95% CI)
W	5307	182	114	1.00 (reference)	4	1.00 (reference)
MW	5516	206	131	1.14 (1.12-1.16)	5	0.90 (0.84-0.97)
S	5639	190	141	1.13 (1.11-1.15)	6	1.07 (1.00-1.14)
NE	5596	206	129	1.30 (1.28-1.33)	11	3.20 (2.99-3.42)

Conclusion: There are substantial regional differences in outcomes for hospitalized injured patients in the US. Investigators must decide whether to apply regional or nationwide standards. We conclude that policy makers will confidently identify best trauma practices through analyses of outcomes of all hospitalized injured patients.

HOSPITAL BASED VIOLENCE INTERVENTION PROGRAMS WORK

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 Associate Professor of Surgery
 University of Maryland School of Medicine, Baltimore, Maryland
 Attending Surgeon
 Director, Violence Intervention Project
 R Adams Cowley Shock Trauma Center, Baltimore, Maryland
 Director of Trauma

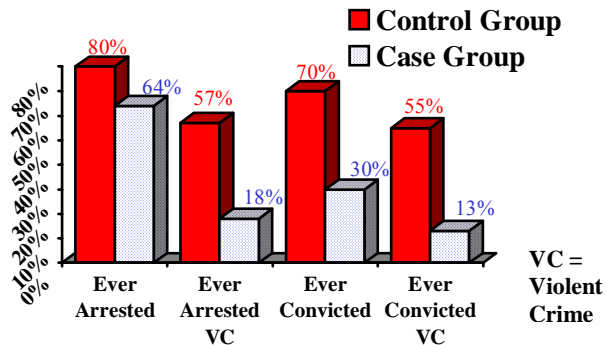
Presenter: Carnell Cooper, M.D.

Invited Discussant: Edward E. Cornwell, III, M.D.

Introduction: Hospital-based violence prevention programs have emerged at trauma centers nationwide; however, none has been thoroughly evaluated for effectiveness. Our Violence Intervention Program (VIP) conducted a prospective randomized control study to evaluate the effectiveness of intervention for repeat victims of violence.

Method: Patients admitted between 1999 and 2002 for treatment of injuries inflicted by a violent act were identified. Repeat victims of violence on parole/probation were invited to join the study. Participants were given a history-gathering questionnaire and randomized into two groups. Cases (intervention [n=56]) received intensive psychosocial follow-up services, substance abuse treatment, and family/group therapy. Controls (non-intervention [n=44]) received standard medical treatment and follow-through in accordance with standard parole/probation procedures.

Results: There was no significant difference in the number of arrests in the two groups. The control group was three times more likely to be arrested for a violent crime, two times more likely to be convicted of any crime, and four times more likely to be



convicted of a violent crime. The projected time of incarceration is significantly longer for the control group. Repeat violent criminal activity was significantly more evident in the control group.

Conclusion: Significant differences exist between the intervention/non-intervention groups in terms of the quantity and severity of criminal activity.

**AGGRESSIVE TRAFFIC ENFORCEMENT:
A SIMPLE AND EFFECTIVE INJURY PREVENTION PROGRAM**

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University Medical Center, Fresno, CA

Presenter: James W. Davis, M.D.

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

Purpose: to investigate whether an aggressive traffic violation enforcement program could reduce motor vehicle crashes, fatalities, fatalities related to speed and decrease injury severity in crash victims treated at the trauma center.

Methods: A vigorous enforcement program was established within the city boundaries using increased traffic patrol officers. Data on citations, collisions, fatal collisions and fatalities related to speed, as well as injury severity from the trauma registry were collected for the year prior to program onset (2002), during the first year (2003) and after full implementation (2004). US Census Bureau information was used for population. Statistical analysis was performed with Chi-square and significance attributed to $p < 0.05$.

Results: There were significant increases in citations issued with marked decreases in motor vehicle crashes, fatalities and fatalities related to speed. There was a decrease in moderate severity injury (ISS 10-16) with an increase in minor injury severity scores (0-9).

Year	2002	2003	2004	p value
Population	432,000	455,000	500,000	
Citations	26,000	65,000	85,000	< 0.001
Collisions	4,502	4,314	4,136	< 0.001
Fatalities	52	46	30	< 0.05 vs. 2002
Speed Fatalities	12	6	3	NS
ISS 0 – 9	112 (48%)	145 (56%)	138 (52%)	.190
ISS 10 - 16	48 (21%)	42 (16%)	33 (12%)	< 0.05

Conclusions: Aggressive traffic enforcement decreased motor vehicle crashes, crash fatalities, fatalities related to speed and decreased injury severity. This is a simple, easily implemented injury prevention program with immediate benefit.

**THE BURDEN OF NON-COMPLIANCE WITH SEAT BELT USE ON A
TRAUMA CENTER**

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Presenter: Andrew J. Kerwin, M.D.

Invited Discussant: Bruce Potenza, M.D.

INTRODUCTION: Non-compliance with seat belt use is well known to result in worse injury. The impact of non-compliance on hospital resource consumption and hospital charges is less well known. This study was carried out to examine the economic burden of non-compliance with seat belt use. **METHODS:** Trauma registry data was reviewed for patients involved in motor vehicle crashes in 2003 and 2004. Routine demographic data was analyzed. Outcome data included hospital length of stay (LOSH), intensive care unit length of stay (LOSI), number of ventilator days (vent days), and mortality. Hospital charges, rate of collection, hospital use (measured by need for admission), operating room (OR) use, and critical care unit (CC) use were calculated to determine the burden of non-compliance with seat belt use. **RESULTS:** 3426 patients were identified for analysis. 1744 were compliant with seat belt use (SEAT) while 1682 were not compliant (NO SEAT). Patients in the NO SEAT group were significantly younger (31.2 vs. 37.4 years) and significantly more severely injured (ISS; 11 vs. 7) than those in the SEAT group. Patients in the NO SEAT group had a significantly longer LOSH (4.4 vs. 2.2) and LOSI (1.4 vs. 0.3) as well as significantly more vent days (1.2 vs. 0.2) than those in the SEAT group. Mortality was more than doubled in the NO SEAT group (2.2 vs. 0.9%) as compared to the SEAT group. Resource consumption was significantly greater in the NO SEAT group as evidenced by increased hospital use (64.9 vs. 39%), increased CC use (22.9 vs. 10.3%) and increased OR use (9.2 vs. 4.9%) when compared to the SEAT group. Subsequently, hospital charges were significantly higher in the NO SEAT group (\$32,138 vs. \$16,547) than in the SEAT group. Charge collection rate was lower in the NO SEAT group (30.5 vs. 42.5%) than in the SEAT group. **CONCLUSIONS:** These data help to quantify the burden placed on a trauma center by non-compliance with seat belt use. These data can be used for education, injury prevention programs, and discussion with legislators for planning of state policy and trauma center funding.

TELEMEDICINE CONSULTATION REDUCES TIME TO TRANSFER SEVERELY INJURED PATIENTS TO A RURAL LEVEL I TRAUMA CENTER

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Presenter: William E. Charash, M.D., Ph.D.

Invited Discussant: Vernon J. Henderson, M.D.

Objective: To evaluate the impact of telemedicine on outcomes following rural trauma. Six emergency departments participate in the teletrauma program at our Level I trauma center. These centers have teleconferencing units in their resuscitation rooms.

Telemedicine is frequently used to facilitate communication between providers during routine trauma calls. Distinct from this application, the referring provider may request the involvement of the trauma surgeon during the initial evaluation and resuscitation of the trauma patient in the form of a teletrauma consultation.

Methods: All teletrauma consultations performed between 4/00 and 8/04 were evaluated. Outcomes for teletrauma patients were compared to ISS matched non-teletrauma patients, during the same time period, using Fisher’s exact test.

Results: 64 teletrauma consultations have been conducted over this time period. Mean ± s.d. age was 36±19 years (range of 1-81 years). 81% of patients were male. Mean ISS was 24.9 (range: 8-75). Mean ± s.d. GCS was 9.9±5.5. 40% of patients had a GCS of < 9. Teleradiology was used in 33% of cases. Mortality was 30% in the teletrauma group compared to 7% in the non-teletrauma group (p<0.001). Complication rate was 34% in the teletrauma group compared to 26% (p=0.3). Time (minutes) between injury and arrival at our trauma center for 5 of the 6 E.D.’s is presented here:

Transfer Time (min)	E.D. 1	E.D. 2	E.D. 3	E.D. 4	E.D. 5	Overall
Teletrauma	401	394	311	214	358	327
Non Teletrauma	421	462	473	277	453	410

P=0.05 (2-way analysis of covariance)

Conclusions: Teletrauma consultations are requested on a severely injured subset of trauma patients. In a rural system of trauma, the interval between injury and patient arrival at the trauma center is long. Early involvement of the trauma surgeon, via telemedicine, can be used to significantly shorten this time interval.

REDUCTIONS IN TRAUMA WORKFORCE AVAILABILITY RESULT IN INCREASED MORBIDITY AND MORTALITY

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Presenter: Joseph P. Minei, M.D.

Invited Discussant: L. D. Britt, M.D.

Introduction: Resident work hour restrictions have been instituted in an effort to improve patient care. Further, cost cutting hospital programs can result in nurse reductions. This study evaluated the impact of workforce reductions on trauma patient outcomes. **Methods:** Trauma outcome data was compared from years 2002 through 2004 in a regional level 1 trauma center that has been continuously verified since 1988. The workforce available hours for residents and trauma nurse clinicians (TNC) were determined for the same years. Outcomes evaluated include: emergency department (ED) dwell time, hospital length of stay (LOS), cost of care and clinical outcomes. **Results:** From 2002 to 2004, trauma admissions increased 20% from 3,969 to 4,788; while the number of TNCs decreased 29% from 21 to 15 in early 2003. This resulted in a decrease in the average time spent by a TNC from 9 to 6 hours/patient during hospitalization. A work flow study, performed in 2004, revealed that only 62% of required nursing care hours were budgeted and with vacancies more than 50% of nursing care hours were unfilled. Prior to implementation of the resident 80 hour work rule in 2003, a typical surgical resident on the trauma service worked over 100 hours per week. This rule resulted in a 20% work hour reduction in resident work hours per week. Neither the number of residents, nor the level of residents changed during this time. The trauma performance improvement process documented a negative impact on performance standards. The ED maximum dwell time standard had an 86% compliance in 2002, 70% in 2003, and 50% in 2004. The average LOS increased from 5.5 days in 2002 to 9.7 days in 2004. The cost of care (patient charges) during this time frame doubled. In addition, preventable and possibly preventable deaths significantly increased. **Conclusions:** The increase in trauma patient volume, combined with decreased work hour availability of the TNC and the surgical residents resulted in worsening of clinical outcomes. Continuous monitoring of system and clinical performance standards are crucial in identifying early trends that impact trauma care.

INCLUSIVE TRAUMA SYSTEMS: DO THEY IMPROVE TRIAGE OR OUTCOMES OF THE SEVERELY INJURED?

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Presenter: Garth H. Utter, M.D.

Invited Discussant: A. Brent Eastman, M.D.

Background: Trauma systems decrease injury-related mortality, but not all systems have the same configuration. In some, nearly all acute care hospitals participate (inclusive systems), while in others, relatively few high level centers participate (exclusive systems). We postulate that inclusive systems assure that severely injured patients are more likely to be triaged to a Level I or II regional trauma center (RTC) and this greater degree of participation would lead to lower mortality.

Methods: We used administrative discharge data for a single year in 25 states with formal systems and included all adults with ISS \geq 16. We categorized states by trauma system configuration (exclusive, more inclusive, most inclusive) based on the proportion of all hospitals designated as a Level I-V trauma center (0-13%, 14-37%, 38-100%, respectively). We compared the rates of triage to a RTC and inpatient death, in inclusive states relative to exclusive states, while adjusting for patient and state level factors.

Results: Out of 58,160 patients, 19,486 (33.5%) were hospitalized at RTCs. Inpatient mortality was 14.6%. After adjusting for patient age, race, mechanism of injury, payer status and state rurality, the odds of triage to a RTC were similar in inclusive and exclusive systems (Table). After adjusting for age, injury mechanism, and payer status, the odds of death were also similar in inclusive and exclusive systems.

System configuration	Triage to RTC (OR, 95% CI)		Mortality (OR, 95% CI)	
	Unadjusted	Adjusted	Unadjusted	Adjusted
Exclusive	Reference	Reference	Reference	Reference
More Inclusive	2.1 (0.6-7.0)	1.1 (0.6-2.0)	1.0 (0.9-1.1)	0.9 (0.8-1.1)
Most Inclusive	2.6 (0.8-8.4)	1.6 (0.8-3.4)	1.0 (0.8-1.1)	0.9 (0.8-1.1)

Conclusions: Severely injured trauma patients are no more likely to reach a regional trauma center in states with inclusive systems, and mortality is comparable to exclusive systems. The inclusive trauma system configuration should be re-evaluated, given the expense and resources required to implement and maintain this system without apparent benefit.

**MAINTAINING PATIENT THROUGHPUT ON AN EVOLVING TRAUMA /
EMERGENCY SURGERY SERVICE**

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Invited Discussant: Felix D. Battistella, M.D.

Background: The case management team (CMT) has been an effective tool to decrease denied days and improve hospital throughput on a trauma service. With the addition of emergency general surgery (EGS) to our practice, we reviewed the ability of the case management team to absorb EGS patients on the inpatient trauma service while maintaining the improvements initially realized.

Methods: An interdisciplinary CMT was implemented in January 1999. CRNPs were added in August 2003 to address ACGME resident work hour restrictions. “Key communications” for each CMT member are reported three times per week as defined by hospital-approved policy. Beginning in August 2001, the trauma service was expanded to include EGS patients. Data from the trauma registry, hospital utilization review, and finance office were analyzed pre (CY 1998 and 1999) and post (CY 2003 and 2004) the addition of EGS. Tests of proportion were used to evaluate questions of interest.

Results: * $p < 0.01$ for CY 1998 and 1999 vs CY 2003 and 2004

DATA ELEMENT	CY 1998	CY 1999	CY 2003	CY 2004
Trauma Service Admissions	1173	1365	1116	1272
Average ISS	11.5	11.8	13.1	13.2
EGS Admissions	--	--	473	561
Total Admissions	1173	1365	1589	1833
Average Hospital LOS (days)	6.0	5.5	6.9	5.8
Total Denied Days	325	214	169	40
% Denied Days*	4.6%	2.8%	1.8%	0.5%
% Readmissions *	4.0%	3.5%	3.0%	1.8%

Conclusions: The initial improvements in patient throughput noted after the introduction of a CMT in January 1999 have been maintained in recent years despite the addition of an EGS component to the trauma service. Percent denied days and readmissions have continued to decrease. The length of stay for these patients remains, in part, dependent on case mix. The CMT plays an integral role in maintaining the efficiency of a trauma / emergency surgery service.

Session VII

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**ASSESSING EFFECTIVENESS OF A MATURE TRAUMA SYSTEM:
ASSOCIATION OF PROXIMITY TO A TRAUMA CENTER WITH LOWER
INJURY MORTALITY RATE**

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Presenter: Linda Papa, M.D.

Invited Discussant: Richard J. Fantus, M.D.

OBJECTIVE: To determine effectiveness of a mature trauma system by comparing motor vehicle crash (MVC) death rates in counties with a trauma center (TC) to those without a TC (NTC). System effectiveness has typically been measured by comparing mortality rates before and after trauma system implementation, an approach not applicable to mature systems. We hypothesize that, in a mature trauma system, proximity to a TC is associated with lower injury mortality.

METHODS: State data for MVC occurring in 2003 were analyzed. Counties with a TC were compared to NTC counties. Primary outcome was fatality rate per injury (per 100,000 population). Fatality rate per crash was used to adjust for rural or urban location. Data from 67 counties and 21 trauma centers were analyzed. Counties with more than one TC were counted once. Data are expressed as proportions with 95% confidence intervals and were analyzed using Fisher's Exact test, independent sample t-tests, Mann Whitney U test and ANOVA. Significance was assumed when a level $\alpha = 0.05$ was observed.

RESULTS: The statewide incidence of fatality from MVC in 2003 was 30.1 per 100,000. TC counties had half the fatality rate compared to NTC counties; 16.7 versus 33.4 per 100,000 (95%CI=11.6-21.8, $p < 0.001$). The overall state fatality *per injury* rate was 2.8% (95%CI= 2.4-3.3). Fatality per injury rate in TC counties was 1.3% vs 3.2% in NTC counties (95%CI=1.4-2.4) ($p < 0.001$). Likewise, fatality *per crash* rate in TC counties was less than half that of NTC counties 1.2% vs. 3.2% (95%CI=1.4-2.5) ($p < 0.001$).

CONCLUSIONS: TC counties had lower MVC death rates than NTC counties. This association was independent of rural vs urban crash location. These observations validate the effectiveness of this mature trauma system and emphasize the need for optimal deployment of trauma centers.

**A COMPARATIVE REVIEW OF TRAUMA SERVICE MODELS
INCORPORATING SURGICAL RESIDENTS VERSUS MID-LEVEL SUPPORT
ON PATIENT CARE AND OUTCOMES AT AN AMERICAN COLLEGE OF
SURGEONS VERIFIED LEVEL I TRAUMA CENTER**

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Stephen D. Helmer, PhD, University of Kansas School of Medicine - Wichita
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Center

Presenter: Luke Y. Shen, M.D.

Invited Discussant: Michael Rhodes, M.D.

Background: As a result of the ACGME implemented work-hour restrictions, many trauma centers have altered their staff structure; some by incorporating mid-level personnel (physician assistants and nurse practitioners). The purpose of this study was to compare trauma care in a trauma service model utilizing surgical residents vs. mid-level personnel.

Methods: Retrospective review of 1-year intervals, before and after modifying the trauma service structure at a Level I Trauma Center was performed. Period I: surgery residents and on-call trauma surgeons managed the trauma service. Period II: residents were replaced with mid-level personnel and required in-house trauma surgeons. Data collected included demographics, injury severity and mechanism, length of stay (LOS), and mortality.

Results: A total of 3,225 patients (mean age 34.1; 58.1% male) were included. Mechanism of injury was blunt in 91.7%. The demographics and injury mechanism for time periods I and II were similar. Patients were more severely injured in period I (ISS: 8.2 vs. 7.6, P=0.06). Outcomes by univariate analysis are shown in the table.

Variable (Mean ± SD)	Period I 1632 pts	Period II 1593 pts	P-value	Period I ISS > 15	Period II ISS > 15	P-value
Hospital LOS (d)	3.0 ± 5.8	3.3 ± 5.7	0.081	9.2 ± 10.4	9.6 ± 9.8	0.70
ICU LOS (d)	4.5 ± 6.8	5.7 ± 5.7	0.23	4.9 ± 8.0	5.1 ± 7.4	0.78
Ventilator Days	5.2 ± 8.6	5.0 ± 7.5	0.83	6.4 ± 9.8	6.4 ± 8.8	0.99
Mortality Rate	5.3%	4.1%	0.13	30.2%	23.8%	0.12

On multi-variate analysis, factors that significantly affected mortality and hospital LOS included age, injury type, severity of injury, and treatment period. Factors significantly affecting ICU LOS included age and injury severity, but not treatment period.

Conclusions: Although patients in period I sustained more severe injuries, multi-variate analysis demonstrated improved mortality rate, but longer length of stay with in-house trauma surgeons and mid-level personnel. Our study indicates that patient care and outcomes are similar for trauma models with surgical residents or mid-level personnel.

**THE EFFECT OF A PROTOCOL OF AGGRESSIVE DONOR MANAGEMENT:
IMPLICATIONS FOR THE NATIONAL ORGAN DONOR SHORTAGE CRISIS**

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Presenter: Ali Salim, M.D.

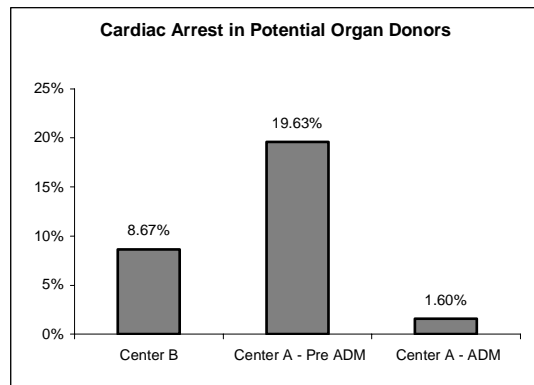
Invited Discussant: Patrick Reilly, M.D.

Background: The disparity between the number of people awaiting organ transplantation and the number of organs available has become a public health crisis. As many as 25% of potential donors are lost due to cardiovascular collapse (CVC) before organ harvest. A policy of aggressive donor management (ADM) will decrease the number of cadaveric donors lost due to CVC.

Methods: Retrospective analysis of potential brain-dead donors evaluated from 1/95 to 12/03 at nine ACS verified Level 1 trauma centers covered by a regional organ procurement agency. One center (center A) had an ADM protocol in place (instituted 1/99), the remaining 8 centers with no ADM protocol were grouped as center B. Incidence of CVC and organ donation demographics were compared between centers and within center A before and after adoption of ADM. ADM consists of a dedicated team, aggressive fluid resuscitation, and hormone replacement therapy with solumedrol and thyroxin

Results: The incidence of CVC was significantly higher in center A pre-ADM (OR 15.0, $p < 0.01$) and center B (OR 5.8, $p < 0.01$) compared to center A with ADM (see fig). The number of organs harvested per potential donor for center A with ADM (2.4) was significantly higher than pre-ADM (2.0, $p = 0.02$) and center B (2.1, $p < 0.01$).

Conclusion: The presence of an ADM protocol is associated with a significant decrease in the number of donors lost due to CVC. This should result in an increased number of organs available for transplantation, at a time when methods for increasing the donor pool are needed.



ROUTINE REPEAT HEAD CT IS UNNECESSARY IN PATIENTS WITH MINOR HEAD INJURY AND A POSITIVE INITIAL HEAD CT

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Presenter: George C. Velmahos, M.D.

Invited Discussant: Michael H. Thomason, M.D.

Background: The need for *routine* repeat head CT (RRH CT), following a positive initial CT, is debated. In the presence of moderate or severe head injury RRH CT is usually obtained due to the unreliability of clinical exam. In patients with minor head injury (GCS: 13-15), who can be evaluated clinically, RRH CT may be unnecessary.

Methods: In a Level 1 urban trauma center with a policy of RRH CT, we reviewed the records of 692 consecutive trauma patients with GCS 13-15 and a head CT (10/04-10/05). Patients with positive and negative RRH CT were compared, and independent predictors of positive RRH CT were identified by using stepwise logistic regression.

Results: Of 692 patients, 187 (27%) had a positive initial head CT and received RRH CT. Worsening of the initial lesion or new lesions were found in 38 patients (20% of 187).

	UNCHANGED RRH CT (N= 149)	WORSENERD RRH CT (N=38)	p- value
Male gender	79 (53%)	24 (63%)	0.7
Age \geq 55 years	54 (36%)	25 (65%)	0.01
ISS \geq 16	95 (64%)	33 (87%)	0.15
AIS Head $>$ 3	90 (60%)	33 (87%)	0.06
Multiple lesions on initial head CT	36 (24%)	28 (74%)	0.001
Hours from injury to initial head CT	4.7 \pm 4.4	2.8 \pm 2.3	0.004
GCS of 15 on admission	99 (66%)	23 (60.5%)	0.69

Age $>$ 55 years (Odds ratio: 2.53, 95% CI: 1.18, 5.39) and multiple lesions on head CT (OR: 3.39, 95% CI: 1.6, 7.2) were independent predictors of a positive RRH CT. Only 7 patients (4% of 187 with positive initial head CT) had an intervention after the worsened RRH CT. All had neurologic deterioration after the initial CT; they would have received an additional head CT, even in the absence of a policy for repeating it routinely.

Conclusions: RRH CT is unnecessary in patients with minor head injury who have a positive initial head CT. Older age and multiple lesions on the initial head CT predict evolution of the existing brain injury. Clinical examination accurately identifies the few patients who may need clinical intervention, following such evolution.

EVALUATION OF THE CERVICAL SPINE IN BLUNT TRAUMA PATIENTS WITH ATTENTION TO THE EAST GUIDELINES

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Presenter: Lou M. Smith, M.D.

Invited Discussant: Frederick A. Luchette, M.D.

Purpose:The Eastern Association for the Surgery of Trauma (EAST) has published guidelines for evaluation of the cervical spine (C-sp). We evaluated the safety/efficacy of EAST guidelines (EG) 3, 4, and 5. **Methods:** Prospective data in a series over 3 yrs.: Jan. 2000-Dec. 2003. Statistical analysis was performed with SAS V8.2 statistical pkg. **Results:** 287 pts with suspected C-sp injury(inj) and persistent neck pain (PNP), neurological deficit (ND),unreliable exam (UE)or obtundation with significant mechanism(ob/sm) completed protocol. All pts had 3 view plain Xrays (3vpX), a CT scan of the C-sp and an MRI of the C-sp. Mean age=32 yrs. 67% male. MVC was the most common mechanism (153 pts.)Mean ISS was 19.6.Mean GCS was 11.2. 161 pts had a nl GCS. Table 1 shows results for these pts with PNP, ND and UE. CT identified 16 inj not seen on 3vpX. MRI was the only positive test in 52 patients. 2 ligamentous inj were seen in PNP pts. In the126 pts.with ob/sm, 80 pts.had all nl studies. 1 patient had a + CT scan and neg

Table 1	PNP	ND	UE
N=	102	25	34
All neg	56	5	32
CT +	10	4	2
MRI+	36	16	0
Lig inj	2	0	0

MRI. 9 pts.had +CT and + MRI and 38 pts.had + MRI only. 2 of those were ligamentous inj. In pts with ob/sm and

abnormality by MRI alone, the GCS was significantly lower (6.2 vs. 11.2, $p<0.01$ Wilcoxon rank sum {wrs}) and the ISS higher (26.4 vs. 19.6, $p<0.01$,wrs). **Conclusions:** Our data support EG 3 as safe for evaluation of PNP. 35% of these pts.will have abnl MRI, only a few of which are unstable. Our data supports EG 4 as safe and effective for evaluation of ND. Also, neg MRI for ND was a 100% prognostic indicator for recovery. Our data does not support EG 5 for op/sm, as 3vpX and CT C-sp may leave some clinically significant C-sp injuries undiagnosed. We support use of MRI to detect these injuries.

**TIMING OF THORACIC SPINE STABILIZATION IN TRAUMA PATIENTS:
IMPACT ON CLINICAL COURSE AND OUTCOME**

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Presenter: Christian Schinkel, M.D.

Invited Discussant: William E. Charash, M.D.

Purpose: Optimal timing of stabilization for thoracic spine injuries in multiple injured patients is still discussed controversial as additional lung injury occurs frequently. Early surgery might be beneficial on clinical course and outcome in this patient population.

Methods: Therefore we analyzed the National Trauma Database (n=8057) and compared clinical parameters and outcome of patients with severe thoracic spine injuries (AIS>2; n=299) that underwent spine stabilization within (group I) or after 72h (group II) post trauma.

Results: 95 % of all patients had an additional severe thoracic injuries like lung contusion or pneumothorax. In spite of comparable demographic data (median (range) age I: 33 (13-80) yrs.; II: 37 (16-66) yrs.; mean ISS I: 29 (9-66) pts.; II: 29 (14-57) pts.; hemoglobin on admission: I: 11.8 (4.9-16.7) mg/dl; II: 10.2 (4.4-15.9) mg/dl; systolic blood pressure on admission: I: 120 (65-190) mmHg; II: 120 (80-170) mmHg; initial GCS I: 13 (3-15) pts.; II: 11 (3-15) pts.) patients in group I had a significant shorter ICU stay (median (range) I: 8 (0-237) d; II: 16 (2-91) d); shorter dependence on mechanical ventilation (I: 2 (0-48) d; II: 5 (0-274) d), and shorter in-hospital stay (I: 22 (1-255) d; II: 32 (6-91) d). Expected mortality calculated by TRISS was significantly reduced in I (calculated: 16.4 %; documented: 6.3 %) but not in II (18.8 % vs. 17 %).

Conclusions: Almost 10% of all patients in the National Trauma Registry had severe spine injuries. The extend of injury was often underestimated in the preclinical setting. There was a 95 % coincidence of severe thoracic injuries in thoracic spine trauma. Our data provide evidence that early stabilization of thoracic spine injuries in trauma patients reduces overall hospital and ICU stay and improves outcome. Thus early stabilization of thoracic spine injuries within 3 days after trauma appear to be favorable.

**NONOPERATIVE MANAGEMENT OF SEVERE BLUNT SPLENIC INJURY:
ARE WE GETTING BETTER?**

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Presenter: Gregory A. Watson, M.D.

Invited Discussant: Christine S. Cocanour, M.D.

Objective: Management of blunt splenic injuries has evolved with nonoperative management (NOM) now the most common method of treatment. Controversy exists regarding NOM in patients with severe splenic injuries. We sought to analyze outcome from severe blunt splenic injuries in adults to determine if success and mortality associated with NOM are improving.

Methods: Adults with severe blunt splenic injury (AIS \geq 4) in the National Trauma Data Bank™ were analyzed from 1996-2001. Patients transferred from the ED to the OR and undergoing a laparotomy were considered operative management (OM) and patients admitted elsewhere were considered NOM. All patients with initial NOM who subsequently required a laparotomy were considered failures.

Results: 3,021 adults were diagnosed with severe blunt splenic injury (19.4% of all blunt splenic injuries). The proportion of splenic injuries classified as severe decreased from 26.2% in 1996 to 16% in 2001 ($p < 0.001$). 61.1 % of patients were treated operatively from the ED. NOM was attempted in 38.9% and no change in frequency of NOM was noted over time. Failure of NOM was 47.1% and did not change but the mortality associated with failure of NOM rose from 4.2% in 1996 to 14.3% in 2001 ($p < 0.05$). Mortality associated with OM was unchanged. Characteristics of patients selected for NOM or who failed NOM were unchanged from 1996-2001. Patients who failed NOM (FNOM) differed significantly from those with successful NOM (SNOM) (* = $p < 0.01$).

	Age	% Male	SBP	ISS	LOS	ICU LOS
SNOM	33.4 +/- 0.4	73.3	122.2 +/- 1.4	28.2 +/- 0.6	9.5 +/- 0.5	3.8 +/- 0.3
FNOM	39.3 +/- 0.8*	67.0	117.8 +/- 1.3*	31.2 +/- 0.6*	15.2 +/- 0.7*	7.7 +/- 0.6*

Conclusions: NOM of severe splenic injuries is associated with a high failure rate. Mortality associated with failure of NOM in patients with severe splenic injuries tripled from 1996 to 2001. Careful judgement must be exercised in applying NOM to patients with severe splenic injuries in order to minimize morbidity.

REPORT ON A NEW TYPE OF TRAUMA FULL BODY DIGITAL X-RAY MACHINE: THE LODOX STATSCAN. A TIME AND MOTION STUDY

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Presenter: Kenneth D. Boffard, M.D.

Invited Discussant: Mark L. Gestring, M.D.

Introduction: A low dose Digital X-Ray machine (Lodox Statscan) was compared with conventional radiography. This unit is capable of a whole body scan in 13 seconds. The Unit was positioned at the entrance to the Emergency Department. Patients were scanned *before* entry into the resuscitation area. The quality and yield of the images provided were compared to those obtained conventionally in the Emergency Room and the time taken for a Statscan was compared to the times taken for conventional imaging.

Methods: 100 consecutive patients were assessed by the duty attending trauma surgeon. Those deemed stable were submitted to Statscan prior to entrance into the resuscitation room. For the first 50 patients, the Statscan images were blinded while the trauma surgeon and an independent radiologist reported on the conventional x-ray images. Thereafter the Statscan images were compared. For the second 50 patients, the procedure was reversed. The times taken for the primary and secondary surveys were documented, with conventional initial radiology as recommended by the ATLS program, and then omitting the conventional films where possible, and substituting them with Statscan information.

Results: There was no difference between the AP images in conventional mode, and Statscan images, and the same information was derived from both modalities. The confidence by trauma surgeons was the same, while radiologists favored conventional imaging. In the lateral modality, the CT spine was clearer using conventional radiography. The time saving using Statscan compared to conventional radiography was 12 minutes.

Discussion: The use of a different form of radiology is discussed. The unit is placed at the entrance to the ED, so that by the time the patient enters the ED, full body radiography is already completed and available. This has significant advantages, particularly with penetrating injury, in that all metal fragments are already displayed at the time that the patient enters the resuscitation area. Resuscitation times are significantly reduced using the technology.

**CYSTOGRAM FOLLOW-UP IN THE MANAGEMENT OF TRAUMATIC
BLADDER DISRUPTION**

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Presenter: Kenji Inaba, M.D.

Invited Discussant: Amy J. Goldberg, M.D.

Background: The utility of obtaining a routine cystogram after the repair of intra-peritoneal bladder disruption prior to urethral catheter removal is unknown. This study was designed to examine whether follow-up cystogram evaluation after traumatic bladder disruption affected the clinical management of these injuries. We hypothesized that routine cystograms, after operative repair of intra-peritoneal bladder disruptions, provide no clinically useful information and can be eliminated in the management of these injuries.

Methods: After IRB approval, our prospectively collected trauma database was retrospectively reviewed for all ICD-9 867.0 and 867.1 coded bladder injuries over a 6 year period ending in 6/04. Demographics, clinical injury data, detailed operative records and imaging studies were reviewed for each patient. Bladder injuries were categorized as intra-peritoneal (IPBD) or extra-peritoneal bladder disruptions (EPBD) based on imaging results and operative exploration. All patients sustaining isolated urethral injury, trigone injury or requiring ureter reimplantation were excluded from further analysis.

Results: 20 647 trauma patients were screened for bladder injury. Out of this group, there were 47 IPBDs and 37 EPBDs. All IPBDs underwent operative repair. Eight of these patients had no post-operative cystogram and all were doing well at follow-up (2-13 weeks). The remaining 39 patients underwent a post-operative cystogram at 15.3 +/- 7.3 days (range 7-36). Evaluation was by CT-cystogram in 26.2% and cystogram in 73.8%. All 39 of the IPBDs with a simple dome disruption or thru and thru penetrating injury had a negative post-operative cystogram. In the EPBD group, 21.6% had positive cystograms and required further follow-up and intervention.

Conclusions: Patients sustaining extra-peritoneal bladder disruptions require routine cystogram follow-up. In those patients sustaining intra-peritoneal bladder disruptions, routine follow-up cystograms did not affect clinical management and are not warranted.

Session VII

Paper 66 11:20

THE SHAPE OF THINGS TO COME: RESULTS OF A SURVEY OF TRAUMA SURGEONS ON ISSUES CONCERNING THEIR FUTURE

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Presenter: Thomas J. Esposito, M.D., MPH

Invited Discussant: Glen A. Franklin, M.D.

INTRODUCTION: This study seeks to characterize the opinions of practicing surgeons as a basis for formulating a plan to restructure the discipline of trauma surgery and its training path. **METHODS:** A 52-item questionnaire was administered to the membership of the AAST, EAST and WTA. The survey tool investigated issues related to current and future practice. **RESULTS:** Response rate was 60%. Mean age was 49 and 88% were male. The average time in practice is 15 years. The average workweek is 80 hours with 48% of that time devoted to clinical practice. About half take in house call and about one-third receive an on-call stipend. The median annual number of major trauma cases was 50. The most important disincentives to entering the field were felt to be lifestyle issues and a limited scope of practice. Almost 90% felt their work as trauma surgeons was undervalued by society and the health care system. The great majority (88%) responded that the discipline of trauma surgery must change. Respondents feel this restructuring should include broader general surgery (83%) as well as limited orthopedic (60%) and neurosurgical trauma-related procedures (59%). About one-half of respondents favored in-house call (54%) and a practice model similar to emergency medicine (55%). Factors that would most enhance practice were thought to be guaranteed appropriate salary and guaranteed time away from work. Training in a broad range of skills was felt to be essential or useful to the trauma surgeon of the future. **CONCLUSIONS:** Current practicing trauma surgeons feel that the discipline must change to remain viable. This change should entail broader training to allow more procedures in trauma, emergency surgery, critical care and elective general surgery. The preferred practice model is a large, hospital-based, diversified group practice with a predictable lifestyle and guaranteed salary commensurate with effort. Inclusion of selected emergency orthopedic and neurosurgical procedures are viewed favorably as is in-house call. Efforts to increase public perception of trauma surgery's value to society and its impending demise are warranted.

Session VII

Paper 67 11:40

INJURED PATIENTS HAVE LOWER MORTALITY WHEN TREATED BY "FULL-TIME" TRAUMA SURGEONS VS. SURGEONS WHO COVER TRAUMA "PART-TIME"

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Presenter: Elliott R. Haut, M.D.

Invited Discussant: William J. Mileski, M.D.

Introduction: Studies examining the effect of trauma surgeon volume on patient outcomes have had disparate results. We hypothesize that “full-time” trauma surgeons would have lower patient mortality rates than surgeons covering for trauma patients “part-time”.

Methods: Retrospective review of 14,169 patients over 6½ years (1/98 – 6/04) from the trauma registry at an urban, university-based level I trauma center. “Full-time” surgeons practiced primarily trauma, emergency surgery, and critical care. “Part-time” surgeons took trauma call, but mainly practiced another type of surgery (eg. general, vascular, transplant). Chi square and multiple logistic regression compared mortality between groups.

Results: On univariate analysis, the sub-group of patients with severe head injury had lower mortality when treated by “full-time” surgeons.

Trauma Patient Mortality: “Full-time” vs. “Part-time” Trauma Surgeons

	“Full-time”	“Part-time”
ALL Trauma Patients	3.3% (308/9397)	3.6% (170/4774)
ED Survivors	1.3% (116/9204)	1.5% (70/4674)
Blunt	1.1% (76/6755)	1.3% (47/3501)
Penetrating	8.4% (216/2569)	9.2% (113/1231)
Immediate Surgery	7.5% (55/729)	7.8% (25/319)
Hypotension (sbp<90mmHg)	64.0% (228/356)	69.3% (113/163)
Severe Head Injury (GCS <9)	50.0% (126/252)	62.6% (82/131) **
ISS > 15	27.4% (249/910)	31.7% (144/455)
ISS > 25	50.5% (187/370)	56.6% (103/182)

(** p<0.05)

Multiple logistic regression showed a 50% increase in mortality for patients treated by “part-time” trauma surgeons when adjusting for age, gender, ISS>15, severe head injury, hypotension, and penetrating mechanism (odds ratio of death 1.48, 95% CI 1.07-2.05, p=0.017). When adjusted for TRISS, mortality was 85% higher for patients in the “part-time” group (odds ratio of death 1.77, 95% CI 1.10-2.85, p=0.019).

Conclusions: Even within an established trauma program treating many injured patients, mortality is significantly lower in patients treated by “full-time” trauma surgeons.