

## THE ACA AND EMERGENCY GENERAL SURGERY CHOLECYSTECTOMIES

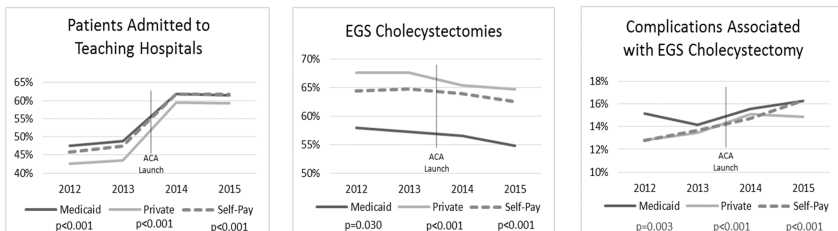
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Invited Discussant: Lance Stuke, MD, MPH

**Introduction:** Gallbladder disease is a common reason for visits to the emergency department and frequently results in emergency general surgery (EGS). The Affordable Care Act (ACA) was landmark legislation enacted in 2014 mandating health insurance coverage for all. The ACA sought to improve access to care and decrease morbidity, mortality and costs. We hypothesize that the ACA shifted EGS to teaching institutions, and that the number of EGS cholecystectomies decreased as access to care improved.

**Methods:** This is a retrospective review using the National Inpatient Sample Database from 2014 through quarter 3 of 2015. Patients age 18-64 who were admitted through the emergency department with a diagnosis of gallbladder disease were identified by ICD-9 codes. Patient demographics, payer type (Medicaid, Private or Self-pay), Charlson Comorbidity Index (CCI), hospital and regional characteristics and were obtained. Outcomes were cholecystectomy, complications, mortality and wage index-adjusted costs. The effect of the ACA was determined by comparing the pre-ACA (2012 & 2013) years to the post-ACA years (2014 & 2015) and included univariate, bivariate and adjusted Difference-in-Differences (DID) analyses.

**Results:** 189,023 patients with gallbladder disease were identified. In the post-ACA period, the proportion of Self-pay admissions decreased from 19.3% to 13.6% (-5.7%,  $p < 0.001$ ) and Medicaid admissions increased from 26.3% to 34.0% (+7.7%,  $p < 0.001$ ). Private insurance admissions did not change significantly. Across all payer categories the proportion of admissions to teaching hospitals increased, the number of EGS cholecystectomies decreased, while complications increased (Figure). The portion of patients with  $CCI \geq 2$  increased significantly in all payer groups (Medicaid 20.0% to 21.1%, Private 13.8% to 15.5% and Self-pay 12.1% to 13.2% all  $p < 0.05$ ). Overall mortality (pre-ACA 0.7% & post-ACA 0.8%,  $p = 0.066$ ) was unchanged within payer groups. Median costs increased significantly for Medicaid and Private insurance while Self-pay was unchanged. Based on adjusted DID analyses the number of EGS cholecystectomies decreased more rapidly for Insured compared to Self-pay patients (-2.7% vs. -1.21%,  $p = 0.033$ ) as did median cost (+\$454.25 vs. +\$113.60,  $p = 0.017$ ).



**Conclusion:** The ACA has changed EGS, shifting the majority of patients to teaching institutions despite insurance type and decreasing the need for EGS cholecystectomy. The trend towards higher complication rate with increased overall cost requires attention. A national registry for EGS will better quantify these outcomes and could direct future initiatives to improve EGS care.

## EMERGENCY GENERAL SURGERY IN GERIATRIC PATIENTS: HOW SHOULD WE EVALUATE HOSPITAL EXPERIENCE?

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Invited Discussant: Jody DiGiacomo, MD

**Introduction:** Emergency general surgery (EGS) remains a significant burden for geriatric patients in the U.S. This study determined if either hospital proportion or annual volume of geriatric patients is associated with outcomes after EGS procedures.

**Methods:** Using AAST criteria, we identified five EGS procedures in the 2012-2015 Nationwide Inpatient Sample in geriatric patients (65+ years old): small bowel resections, large bowel resections, peritoneal adhesiolysis, control of GI ulcer and bleeding, and laparotomy. We defined hospital volume as the absolute number of geriatric patients undergoing EGS procedures, where hospital proportion referred to the ratio of geriatric patients among all EGS procedures. To remove outliers, we excluded the top and bottom 5% of hospitals by proportion of geriatric patients. Hospitals were then divided into quartiles both by proportion and by volume of geriatric patients. Logistic regressions compared four outcomes between these quartiles: mortality, complications, failure-to-rescue (FTR, death after a complication), and extended length of stay (eLOS, procedure-specific top decile of patients). All regressions adjusted for both hospital proportion and volume of geriatric patients, confounding factors, and clustering.

**Results:** We identified 25,084 EGS procedures in geriatric patients at 3528 hospitals (mortality: 10.6%, complications: 30.5%, FTR: 27.7%, eLOS: 9.1%). The median hospital proportion of geriatric patients among EGS procedures was 42.8% (IQR: 33.3% to 52.2%), whereas the median hospital volume of these patients was 14/year (IQR: 8/year to 19/year). After adjustment, the lowest hospital proportion quartile relative to the highest was associated with adverse outcomes: mortality (OR 1.21 [95%-CI 1.03-1.44]), complications (OR 1.16 [1.05-1.29]), FTR (OR 1.32 [1.08-1.63]), and eLOS (OR 1.30 [1.12-1.50]). In contrast, the lowest volume quartile relative to the highest was not associated with adverse outcomes (Table). Procedure-specific analyses revealed similar findings. On sensitivity analyses, as the hospital proportion of geriatric patients increased by 10%, the odds of all adverse outcomes decreased as follows: mortality by 7%, complications by 4%, FTR by 9%, and extended LOS by 8%.

Complex EGS Procedures	Lowest quartile relative to highest (ref) Adjusted odds ratio (95%-CI)	P-value
Hospital quartiles by geriatric PROPORTION		
Mortality	1.21 (1.03-1.44)	*0.024
Complications	1.16 (1.05-1.29)	*0.004
Failure-to-rescue	1.32 (1.08-1.63)	*0.008
Extended LOS	1.30 (1.12-1.50)	*0.001
Hospital quartiles by geriatric VOLUME		
Mortality	1.08 (0.88-1.32)	0.452
Complications	1.02 (0.90-1.16)	0.709
Failure-to-rescue	1.09 (0.86-1.38)	0.490
Extended LOS	0.98 (0.82-1.17)	0.815

Regressions adjusted for both hospital proportion of and hospital volume of geriatric EGS patients, patient age, gender, race, number of comorbidities, payer, malignancy, sepsis, EGS procedure, academic institution, region, beds, and hospital clustering.

\*P<0.05 depicts significance.

**Conclusion:** Higher hospital proportion of geriatric EGS patients, rather than hospital volume, is associated with better postoperative outcomes. These findings have potential implications for benchmarking endeavors.

## THE ACUTE ABDOMEN: FASTER AND SAFER WITH ACUTE CARE SURGERY

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Invited Discussant: Brandon Bruns, MD

**Introduction:** There have been studies comparing outcomes between acute care surgery (ACS) and traditional call models (TRAD) treating common surgical problems such as acute appendicitis and acute cholecystitis. However, there is no data comparing these call models for outcomes of patients with the complex acute abdomen. We hypothesized that the ACS model would lead to more prompt care and fewer complications than the TRAD model. The purpose of this study was to compare outcomes, patient flow and cost between an ACS and TRAD model in the same community when treating the acute abdomen.

**Methods:** The study was performed at two different medical centers in the same hospital system; one a Level I Trauma center using an in house ACS call model, the other a community hospital using a TRAD home call model. Medical records were searched for ICD-9 codes, ICD-10 codes and CPT codes for the diagnoses of perforated viscus, incarcerated with possible strangulated hernia, and diverticulitis with peritonitis requiring emergent surgery from October 2011 through December 2017. Patients not requiring emergent surgery were excluded. ACS and TRAD models were compared using demographic data, time intervals to treatment, outcomes and cost.

**Results:** Over the study period, 1,465 patients had ICD-9, -10 or CPT codes meeting screening criteria and 1,195 did not require emergent surgery leaving 269 patients in the study cohort. There were 201 patients from the ACS center and 68 from the TRAD center with similar rates of perforated viscus, hernia with possible strangulation and diverticulitis requiring surgery. Time to surgeon at bedside was 46 min vs. 126 min ( $p < 0.001$ ) and time from consult to operating room was 231 min vs. 309 min ( $p = 0.011$ ) respectively. The American Society of Anesthesiologists (ASA) physical status classification score was higher in the ACS group ( $p = 0.011$ ). While hospital length of stay and cost were equivalent, the complication rate was significantly lower in the ACS group (27% vs. 44%;  $p = 0.01$ ).

	ACS	TRAD	<i>P-value</i>
<b>Same Size (n)</b>	201	68	
<b>Time to Bedside (min)</b>	46 [25-90]	126 [71-308]	<0.001
<b>Time to OR (min)</b>	231 [156-360]	309 [173-520]	0.01
<b>Length of Stay (days)</b>	7 [4-11]	7 [3-10]	0.12
<b>Complications</b>	55 (27%)	30 (44%)	0.01
<b>Mortality (%)</b>	14 (7%)	5 (7%)	0.91
<b>Cost (\$)</b>	\$15241 ± \$17651	\$16221 ± \$24896	0.39

**Conclusion:** ACS was superior to TRAD when treating more complex abdominal surgical emergencies with faster time to evaluation and reduced complications rates while cost remained equivalent.

## **OUTCOMES IN ADHESIVE SMALL BOWEL OBSTRUCTION FROM A LARGE STATEWIDE DATABASE: WHAT TO EXPECT AFTER NON-OPERATIVE MANAGEMENT**

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Invited Discussant: Jose Diaz, MD

**Introduction:** Although adhesive small bowel obstruction (ASBO) is frequently managed non-operatively, little is known regarding outcomes on readmission following this approach. We used a large-scale population-based database to examine patients readmitted for ASBO who were initially managed non-operatively. We evaluated the risk factors for operative intervention and mortality at readmission.

**Methods:** ASBO patients were identified from the California Office of Statewide Health Planning and Development 2007-2014 discharge dataset. Patients who at primary admission were either managed operatively or had an ICD-9 code for a chronic or obstructive small bowel disease (e.g., Crohn's, hernia) were excluded. Associations between risk factors and both operative intervention and death following readmission were evaluated using backward stepwise logistic regression.

**Results:** Of the 18,408 ASBO patients, we identified 3,656 (19.9%) who were readmitted. Most were female (61.7%) and Caucasian (72.7%). Median age was 67 years (range 18-102). The 1,474 (40.3%) requiring operation at readmission were younger (67 vs 69,  $p=0.001$ ) and presented sooner (157 vs 320 days,  $p<0.001$ ). After adjustment, variables found protective against operative intervention were age  $\geq 65$  years (OR 0.84, 95%CI 0.73-0.96) and readmission after one year (OR 0.64, 95%CI 0.56-0.73). Risk of operative intervention was associated with Hispanic ethnicity (OR 1.27, 95%CI 1.06-1.50) and LOS  $>2$  days at index admission (OR 1.41, 95%CI 1.23-1.62). Patients at greater risk for death were  $\geq 65$  years old (OR 5.12, 95%CI 2.62-10.01), were managed operatively (OR 3.93, 95%CI 2.00-7.70), and had a readmission LOS  $>7$  days (OR 2.47, 95%CI 1.37-4.46). Being discharged home after initial non-operative management was protective against death in the adjusted multivariate model (OR 0.51, 95%CI 0.30-0.87).

**Conclusion:** In this large-scale study of patients readmitted for ASBO who were initially managed non-operatively, those readmitted within a year were at greater risk for operative intervention, and those who were ultimately managed operatively had a higher risk of death. Prospective research is needed to further delineate outcomes associated with initial non-operative management of ASBO.

**EGS PRESENTS GREATER FINANCIAL RISK THAN TRAUMA**

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Invited Discussant: Oliver Gunter, MD

**Introduction:** Trauma and emergency general surgery (EGS) are two main pillars in acute care surgery (ACS). EGS involves an older and more comorbid population and therefore be associated with greater financial risk. We sought to determine the relative profitability of trauma and EGS be analyzing cost and revenue.

**Methods:** Data were extracted from our healthcare data warehouse and the inpatient finance database for emergency admissions  $\geq 18$  years to ACS Service at our referral level 1 trauma center from 1/1/2015 to 12/31/2016. Outcomes, financial metrics, payor, case mix index (CMI) and diagnosis-related group (DRG) were collected. Uninsured patients were excluded. Complex care was defined as multiple services involved.

**Results:** There were 2216 EGS and 3249 trauma admissions. Trauma were more likely to be admitted to the ICU (42% vs 32%,  $p < .001$ ) but length of stay (LOS), ICU LOS and mortality were the not different (Table). Complex care was more common in EGS. Trauma were more likely to have managed care insurance ( $p < .001$ ). EGS had lower CMI, total cost, direct cost and indirect cost. But revenue for EGS was far lower than trauma, resulting in lower contribution margin (revenue – direct cost) and net profit (net revenue – total cost).

**Conclusions:** Though outcomes are similar, EGS is associated with more care complexity and narrower profit margin than trauma. Much higher revenue and net profit in trauma is likely related to payor mix. Government insurance, more common in the older EGS population, makes EGS less profitable. Cost reduction and revenue optimization strategies more even more important in EGS in order to maintain a positive margin.

Table: Differences between EGS and Trauma Admissions

Variable	EGS	Trauma	P-value
<b>No. of Patients</b>	<b>2,216</b>	<b>3,249</b>	
<b>ICU admission, %</b>	33.0%	41.6%	<0.0001
<b>In ICU admits, ICU Days, avg. (SD)</b>	5.6 (7.9)	5.3 (7.7)	0.4073
<b>Complex Care, %</b>	7.6%	4.6%	<0.0001
<b>LOS, avg. (SD)</b>	8.5 (12.0)	8.6 (11.5)	0.3462
<b>Mortality, %</b>	4.6%	4.0%	0.2216
<b>Payor Group, %</b>			<0.0001
<b>Managed Care</b>	21.8%	50.3%	
<b>Medicaid</b>	35.0%	27.9%	
<b>Medicare</b>	43.2%	21.8%	
<b>Case Mix Index, avg. (SD)</b>	2.408 (2.674)	3.053 (3.327)	<0.0001
<b>Total Costs, avg. (SD)</b>	22,196 (35,018)	27,453 (36,599)	<0.0001
<b>Direct Costs</b>	13,806 (22,557)	17,259 (24,161)	<0.0001
<b>Indirect Costs</b>	8,390 (12,555)	10,194 (12,553)	<0.0001
<b>Total Costs/CMI</b>	8,885 (8,457)	9,354 (8,192)	0.0006
<b>Net Revenue</b>	23,119 (40,341)	34,731 (47,318)	<0.0001
<b>Net Revenue/CMI</b>	9,762 (6,714)	12,364 (11,315)	<0.0001
<b>Contribution Margin</b>	9,313 (25,316)	17,473 (32,627)	<0.0001
<b>Net Profit</b>	923 (23,854)	7,279 (30,388)	<0.0001

## Quantifying the Thousands of Lives Lost Due to Poor Emergency General Surgery (EGS) Outcomes: Why We Need A National EGS Quality Improvement Program

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Invited Discussant: Angela Ingraham, MD

**Introduction:** Nearly 4 million Americans present with an Emergency General Surgery (EGS) condition annually, facing significant morbidity and mortality. Unlike elective surgery and trauma, there is no dedicated national quality improvement program to improve EGS outcomes. Our objective is to estimate the number of lives that could potentially be saved through EGS quality improvement in the United States.

**Methods:** Adults with AAST-defined EGS diagnoses were identified in the Nationwide Emergency Department Sample 2006-2014. Hierarchical logistic regression was performed to benchmark treating hospitals into reliability adjusted mortality quintiles. Weighted generalized linear modeling was used to calculate the relative-risk of mortality at each hospital quintile, relative to best-performing quintile. We then calculated the number of excess, potentially preventable deaths at each hospital quintile versus the best-performing quintile using techniques that have previously been used to quantify preventable trauma deaths.

**Results:** Twenty six million EGS patients were admitted and 6.5 million (25%) underwent an operation. In-hospital mortality varied from

0.3% to 4.1% across the treating hospitals. If all hospitals had outcomes similar to those in the best-performing quintile, 158,177 lives could be saved. Overall, 47% of excess deaths occurred at the worst-performing hospitals, while 27% of all excess deaths occurred among the operative cohort.

**Conclusion:** Nearly 200,000 deaths could potentially be prevented in just over a decade if EGS outcomes were improved across the nation. A national initiative to enable structures and processes-of-care associated with optimal EGS outcomes is urgently needed to achieve “Zero Preventable Deaths after Emergency General Surgery.”

**National Estimate of the Number of Excess Emergency General Surgery Deaths**

Quintile of Reliability Adjusted Mortality Rate	Excess Deaths Among All EGS Patients*	Excess Deaths Among Operative EGS Patients*
1 <sup>st</sup> Quintile "Best Performing Hospital Quintile"	Reference	Reference
2 <sup>nd</sup> Quintile	16,981 (15,815-18,117)	3,866 (3,320-4,386)
3 <sup>rd</sup> Quintile	25,254 (24,171-26,310)	6,257 (5,742-6,748)
4 <sup>th</sup> Quintile	41,481 (40,292-42,643)	10,984 (10,431-11,513)
5 <sup>th</sup> Quintile "Worst Performing Hospital Quintile"	74,462 (73,231-75,666)	21,471 (20,896-22,023)
<b>Total Number of Excess EGS Deaths**</b>	<b>158,177</b> <b>(153,509-162,736)</b>	<b>42,577</b> <b>(40,389-44,670)</b>

\* Estimate with 95% confidence interval

\*\*over nine years of Nationwide Emergency Department Sample (NEDS) 2006-2014

**IMPACT OF A  
SIMPLIFIED MANAGEMENT ALGORITHM ON OUTCOME FOLLOWING  
EXSANGUINATING PELVIC FRACTURES: A 10-YEAR EXPERIENCE**

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Invited Discussant: David Morris, MD

**Introduction:** Optimal management of exsanguinating pelvic fractures, specifically with respect to stabilization (external pelvic fixation, pelvic orthotic device) and hemorrhage control (angiography) remains controversial. Our previous experience suggested that management decisions based on a defined algorithm were associated with a significant reduction in transfusion requirements and mortality. Based on these outcomes, a clinical pathway for the management of exsanguinating pelvic fractures was developed. The purpose of this study was to evaluate the impact of this pathway on outcomes.

**Methods:** Consecutive patients over 10 years with blunt pelvic fractures (including vascular disruption, open book component with symphysis diastasis, or sacroiliac disruption with vertical shear) subsequent to the implementation of the clinical pathway were identified. Data regarding patient characteristics, mechanism and severity of injury, severity of shock, adherence to the pathway and outcomes including resuscitative transfusions and mortality were recorded. Patients with hemodynamically unstable pelvic fractures are managed initially with a pelvic orthotic device (POD). For those with continued hemodynamic instability and no extra-pelvic source of hemorrhage, pelvic angiography was performed followed by elective pelvic fixation. Patients managed according to the pathway (PW) were compared to those patients whose management deviated from the pathway (DEV).

**Results:** 3467 patients with pelvic fractures were admitted. 312 (9%) met entry criteria: 246 comprised the PW group and 66 the DEV group. Injury severity, as measured by ISS (35 vs 36,  $p=0.55$ ) and admission GCS (10 vs 10,  $p=0.58$ ), and severity of shock, as measured by admission BE (-7.4 vs -6.4,  $p=0.38$ ) and admission SBP (107 vs 104,  $p=0.53$ ), were similar between the groups. There was also no significant difference in PRBC requirements during initial resuscitation (6.1 vs 6.6 units,  $p=0.22$ ). POD use was only 48% in the DEV group ( $p<0.001$ ). Only 24% of the PW group required angiography compared to 74% of the DEV group ( $p<0.001$ ). Both 48-hour transfusions (11 vs 16,  $p=0.01$ ) and mortality (35% vs 48%,  $p=0.04$ ) were reduced in the PW group compared to the DEV group. Pathway adherence was identified as an independent predictor of both decreased transfusions ( $\beta =-5.8$ ,  $p=0.002$ ) via multiple linear regression and decreased mortality (OR 0.38; 95%CI 0.14-0.51) via multivariable logistic regression after adjusting for age, gender, injury severity and severity of shock.

**Conclusion:** Adherence to a defined clinical pathway simplified the management of exsanguinating pelvic fractures and contributed to a reduction in both transfusion requirements and mortality. Use of this pathway has facilitated the rapid control of life-threatening pelvic hemorrhage while providing the opportunity for definitive operative fixation in a more controlled fashion. In fact, by consistently managing these complex pelvic fractures according to a defined algorithm, an acceptably low morbidity and mortality can be achieved and maintained.

## BLUNT SMALL BOWEL PERFORATION (SBP): A MULTICENTER UPDATE 15 YEARS LATER

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Invited Discussant: Stephen Gale, MD

**Introduction:** Previous work demonstrated delays in the diagnosis of blunt SBP with increased mortality associated with inability of CT scans to reliably exclude the diagnosis. We conducted a follow-up multicenter study to determine if these challenges persist 15 years after the original study.

**Methods:** This multi-center study selected adult cases with ICD-9 CM code for blunt SBP=863.20, no other major injury and at least one abdominal CT within the initial 6 hours. Cases were matched to controls who did not have SBP. Hospital and individual patient data from each center were collected and analyzed. All centers had IRB approval.

**Results:** Data were available from 39 centers (33 had SBP cases) with 127,919 trauma admissions and 94,743 trauma activations from 10/2013 to 9/2015. 25 centers were Level 1. There were 77 cases (mean age 39, 67.5% male, mean LOS 11.2) and 131 matched controls (mean age 44, 64.9% male with LOS 3.6). SBP cases were 0.06% of admissions and 0.08% of activations. Mean time to surgery was 8.43 hours (median 3.68, IQR

1.95-10.33). Initial CT scan showed free air in 31 cases (40%) and none in controls (table). Initial CT scan was within normal limits in 3 case patients (4.2%) and 84 controls (64%). 5 case patients had a second CT scan; two showed free air (one had an initial normal CT scan). One death occurred among the case patients (mortality rate 1.3%) with a time to surgery of 13.8 hours. Multivariate logistic regression analysis showed that abdominal tenderness, abdominal distention, peritonitis, bowel wall thickening, free fluid and contrast extravasation were significantly associated with SBP.

**Conclusion:** Blunt SBI remains relatively uncommon and continues to present a diagnostic challenge 15 years after our initial multicenter study. Trauma centers appear to have shortened time to surgical intervention with an associated decrease in case mortality. Initial CT scans continue to miss a small

but significant number of cases with potentially serious consequences making heightened awareness of this injury and continued clinical vigilance paramount.

1 <sup>st</sup> CT Findings		CONTROL	CASE	P
Free fluid	No	120 (91.6%)	12 (16.7%)	<0.001
	Yes	11 (8.4%)	60 (83.33%)	
Free air	No	131 (100%)	41 (56.9%)	<0.001
	Yes	0 (0%)	31 (43.1%)	
Bowel wall thickening	No	130 (99.2%)	45 (62.5%)	<0.001
	Yes	1 (0.76%)	27 (37.5%)	
Mesenteric stranding	No	130 (99.2%)	55 (76.39%)	<0.001
	Yes	1 (0.76%)	17 (23.61%)	
Contrast extrav	No	130 (99.2%)	64 (88.9%)	0.001
	Yes	1 (0.76%)	8 (11.1%)	
Solid organ injury	No	119 (90.8%)	67 (93.1%)	0.79
	Yes	12 (9.16%)	5 (6.94%)	
Retroperitoneal blood	No	126 (96.2%)	66 (91.67%)	0.2
	Yes	5 (3.82%)	6 (8.3%)	
Chance fracture	No	129 (98.5%)	70 (97.2%)	0.62
	Yes	2 (1.53%)	2 (2.8%)	
Other	No	96 (73.3%)	56 (77.8%)	0.5
	Yes	35 (26.7%)	16 (22.2%)	



**THE NEED FOR TRAUMA INTERVENTION (NFTI) DEFINES MAJOR TRAUMA MORE ACCURATELY THAN INJURY SEVERITY SCORE (ISS) AND REVISED TRAUMA SCORE (RTS): DATA FROM A COLLABORATION OF 35 ADULT AND PEDIATRIC TRAUMA CENTERS.**

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Invited Discussant: William Hoff, MD

**Introduction:** A patient’s trauma burden is dependent on anatomic injury, physiologic derangement, and depletion of reserve. Major anatomic injury is typically defined as ISS >15 and major physiologic derangement defined as RTS <4, but there is no common measure of reserve. The Need For Trauma Intervention (NFTI) was developed to identify early consumption of critical resources—thought to reflect major depletion of reserve—based on: (1) receiving PRBC within four hours of arrival; (2) discharge from the ED to the operating room within 90 minutes; (3) discharge from the ED to interventional radiology; (4) discharge from the ED to the ICU with ICU length of stay (LOS) ≥3 days; (5) therapeutic mechanical ventilation within three days; or (6) mortality within 60 hours. Patients meeting any of these criteria are classified NFTI+ and considered to have severely depleted reserves given their need for emergent intervention and/or early mortality. We hypothesized that NFTI would be a better predictor of outcomes and resource requirements than ISS or RTS.

**Methods:** 35 adult and pediatric US trauma centers submitted data for 88,083 patients. Generalized estimating equations with robust standard errors modeled the effects of ISS >15, RTS <4, and NFTI+ on the odds of mortality, complication, and receiving a full trauma team activation (TTA), as well as LOS and number of procedures performed in 3 days. All models controlled for these three definitions of major trauma, as well as age,

mechanism of injury, and hospital.

**Results:** For all outcomes except receiving full TTA, NFTI was a significantly better predictor than ISS or RTS. The odds of receiving full TTA were highest with RTS, however,

		Mortality	Complication	Full TTA	Total LOS	Procedures in 3 days
ISS >15	OR/Beta (95% CI)	3.32 (3.00, 3.68)	2.08 (1.83, 2.36)	2.76 (2.31, 3.31)	3.12 (2.66, 3.57)	3.03 (2.39, 3.67)
	Wald $\chi^2$ (p-value)	23.15 (<0.001)	11.25 (<0.001)	11.05 (<0.001)	13.30 (<0.001)	9.32 (<0.001)
RTS <4	OR/Beta (95% CI)	16.87 (14.73, 19.32)	1.27 (1.12, 1.44)	30.63 (9.91, 94.63)	-0.92 (-3.04, 1.19)	-0.73 (-2.18, 0.72)
	Wald $\chi^2$ (p-value)	40.82 (<0.001)	3.81 (<0.001)	5.95 (<0.001)	-0.86 (0.392)	-0.99 (0.323)
NFTI+	OR/Beta (95% CI)	20.31 (17.89, 23.05)	3.01 (2.54, 3.57)	6.13 (5.10, 7.36)	5.02 (4.32, 5.71)	4.46 (3.51, 5.41)
	Wald $\chi^2$ (p-value)	46.58 (<0.001)	12.67 (<0.001)	19.34 (<0.001)	14.20 (<0.001)	9.20 (<0.001)

RTS’s large confidence intervals and smaller Wald  $\chi^2$  indicate its predictions may be less reliable. Further, RTS was not predictive of LOS or number of procedures in 3 days.

**Conclusion:** In this multicenter study, NFTI out-performed the standard anatomic and physiologic definitions of major trauma. By determining depletion of reserve via resource consumption, NFTI appears to be less affected by the idiosyncrasies that confound ISS and RTS (e.g., frailty, comorbidities). NFTI+, therefore, appears to be a better definition of major trauma than ISS >15 and RTS <4. Use of NFTI may enable improved triage monitoring and better case-mix adjustment.

## **DIAGNOSIS OF DIAPHRAGM INJURIES USING MODERN 256 SLICE CT SCANNERS: TOO EARLY TO ABANDON OPERATIVE EXPLORATION**

Rindi Uhlich MD, Parker Hu MD, Jeffrey Kerby\* MD,Ph.D., Patrick Bosarge MD,  
University of Alabama Birmingham

Invited Discussant: Alok Gupta, MD

**Introduction:** Missed injury of the diaphragm may result in hernia formation, enteric strangulation, and death. Compounding the problem, diaphragmatic injuries are rare and difficult to diagnose with standard imaging. Consequently, for patients with high suspicion of injury, operative exploration remains the gold standard for diagnosis. As no current data exists, we sought to perform a pragmatic evaluation of the diagnostic ability of 256-slice multi-detector CT scanners for diagnosing diaphragmatic injuries after trauma.

**Methods:** A retrospective review of trauma patients from 2011-2018 with acute diaphragm injury was performed at an ACS verified Level 1 trauma center. Two separate levels of CT scan technology, 64-slice and 256-slice, was used during this time period. Patients without standard CT imaging prior to operative intervention were excluded. Imaging reports were reviewed for the diagnosis of diaphragm injury. Injuries were subsequently graded using operative description per AAST guidelines. Patient demographics, injury patterns, operative details, and outcome results were further recorded.

**Results:** Two-hundred fifty-nine patients were identified with 62.5% (162/259) receiving preoperative CT scan. The majority underwent 64-slice CT (138/162, 85.2%). Comparing patients receiving 64 or 256-slice CT scan, there was no difference in the side of injury (left side 57.5% vs. 70.8%,  $p = 0.43$ ) or median injury grade [3 (3, 3) vs. 3 (2, 3)]. 256-slice CT successfully diagnosed diaphragm injury in 58.3% (14/24) while 64-slice CT identified 47.0% (63/138) of injuries. The false negative rate was lower with 256-slice than 64-slice CT (43.5% vs. 53.8%) overall, among left sided injuries (37.5% vs. 54.2%), and both blunt (16.7% vs. 33.3%) or penetrating (47.1% vs. 62.1%) mechanisms of injury.

**Conclusion:** New 256-slice multi-detector CT offers improved diagnostic sensitivity in comparison to 64-slice CT. However, given the continued high false negative rate of the 256-slice CT scanner, operative exploration is still required for high suspicion of injury.

## **HOW SAFE AND EFFECTIVE ARE SMALL-BORE CHEST TUBES AT MANAGING DELAYED HEMOTHORACES COMPARED TO LARGE-BORE CHEST TUBES?**

John Cordero MD, Alessandro Orlando MPH, Rebecca Vogel MD, Matthew M. Carrick\* MD, Allen Tanner II, MD, David Bar-Or MD, St. Anthony Hospital

Invited Discussant: Ali Salim, MD

**Introduction:** LB tubes are the standard treatment for emergent hemothoraces (HTXs), but treatment of delayed HTXs remains variable. Previous studies have suggested that small bore (SB,  $\leq 14$ Fr.) pigtail tubes have the same efficacy for treating traumatic HTXs as large bore (LB,  $>14$ Fr.) tubes, but data continues to be insufficient. The goal of our study was to analyze the outcomes of SB tubes in patients with delayed HTX. We hypothesized that SB tubes would be as safe and effective as LB tubes.

**Methods:** This was a retrospective observational study across 7.5yrs at 3 Level 1 trauma centers. We included patients 1) diagnosed with a HTX, or multiple rib fractures with bloody effusion from chest tube; 2) with an initial chest tube placed  $\geq 36$ h from hospial arrival. We excluded tubes placed for hemopneumothoraces. SB tubes were compared to LB tubes. The primary outcome was tube failure (requiring an additional/replacement tube or video-assisted thoracoscopy [VATS]). Secondary outcomes were tube falling out or clogging, pleural empyema, pneumonia, retained HTX (persistent heterogeneous fluid collection detected by CT  $\leq 14$ d from initial chest tube placement and requiring intervention), time on chest tube, return to prior function (obtained from discharge physical therapy note), and in-hospital mortality. Patients could have had more than one tube in this study and possibly had bilateral tube placement. Dependent and independent analyses were used to assess primary and secondary outcomes. A repeated measures mixed model compared the mean time each tube was placed by tube group (SB vs. LB); the facility was included as a random effect. All tests were two-tailed with an alpha of 0.05. This study was IRB-approved at all sites.

**Results:** There were 161 SB patients (196 tubes) and 38 LB patients (46 tubes). There were no significant differences between study groups in 13 demographic or injury characteristics. 23 patients had bilateral chest tubes. The median (IQR) tube size for each group was as follows: SB [12Fr. (12-14)] and LB [32Fr. (28-32)]. There was no significant difference in SB and LB groups in the mean (SE) time each tube was in place (91 [24.2] vs. 118 [50.7] hrs,  $p=0.63$ ). The failure rate of SB tubes was significantly smaller than LB tubes (7% vs. 20%,  $p<0.001$ ). LB tubes placed in the operating room had nearly 3-fold the failure rate of those placed at the bedside (33% vs. 12%). SB tubes placed in interventional radiology (IR) had 2-fold the failure rate of those placed at the bedside (9% vs. 5%). SB tubes clogged or fell out significantly more often than LB tubes (4% vs. 0%,  $p<0.001$ , both); clogged SB tubes ranged 10–14Fr, while those that fell out ranged 12–14Fr. There was no significant difference between SB and LB tubes in rates of retained HTX (14% vs. 13%,  $p=0.86$ ), pneumonia (9% vs. 0%,  $p=0.08$ ), in-hospital mortality (1% vs. 5%,  $p=0.09$ ), or returning to prior function (36% vs. 26%,  $p=0.27$ ).

**Conclusion:** SB tubes had a significantly smaller failure rate, similar complication rates, and similar return to prior function rate, compared to LB tubes; however, SB tubes were significantly more prone to clogging and falling out. The median size of SB tubes in this study was smaller than those previously reported in the literature. Our multi-center data lend support to the use of SB tubes for the management of delayed HTXs.

**COMPARISON OF 7 AND 11-12 FRENCH ACCESS FOR REBOA: RESULTS FROM THE AAST AORTIC OCCLUSION FOR RESUSCIATION IN TRAUMA AND ACUTE CARE SURGERY (AORTA) REGISTRY**

Joseph J. DuBose\* MD, Jonathan Morrison MD, Megan Brenner\* MD, Laura Moore\* MD, John Holcomb\* MD, Kenji Inaba\* MD, Jeremy Cannon\* MD, Mark Seamon\* MD, David Skarupa\* MD, Ernest Moore\* MD, Chuck Fox\* MD, Joseph Ibrahim MD, Thomas M. Scalea\* MD, Uniformed Services University Of The Health Sciences

Invited Discussant: Michael Sise, MD

**Introduction:**The introduction of low profile devices designed for Resuscitative Endovascular Balloon Occlusion of the Aorta (REBOA) after trauma has the potential to change practice, outcomes and complication profiles related to this procedure.

**Methods:**The AAST Aortic Occlusion for Resuscitation in Trauma and Acute Care Surgery (AORTA) registry was utilized to identify REBOA patients from 16 centers -comparing presentation, intervention and outcome variables for those REBOA via traditional 11-12 F access platforms and trauma-specific devices requiring only 7 F access.

**Results:**From Nov 2013-Dec 2017, 242 patients with completed data were identified, constituting 124 7F and 118 11-12F uses. Demographics of presentation were not different between the two groups, except that the 7F patients had a higher mean ISS (39.2 vs. 34.1,  $p = 0.028$ ). 7F device use was associated with a lower cut-down requirement for access (22.6% vs. 37.3%,  $p = 0.049$ ) and increased ultrasound guidance utilization (29.0% vs. 23.7%,  $p = 0.049$ ). 7F device afforded earlier aortic occlusion in the course of resuscitation (median 25.0 mins vs. 30 mins,  $p = 0.010$ ), and had lower median PRBC (10.0 vs. 15.5 units,  $p = 0.006$ ) and FFP requirements (7.5 vs. 14.0 units,  $p = 0.005$ ). 7F patients were more likely to survive 24 hrs (58.1% vs. 42.4%,  $p = 0.015$ ) and less likely to suffer in-hospital mortality (57.3% vs. 75.4%,  $p = 0.003$ ). Finally, 7F device use was associated with a 4X lower rate of distal extremity embolism (20.0% vs. 5.6%,  $p = 0.014$ ; OR 95% CI 4.25 [1.25-14.45]) compared to 11-12F counterparts.

**Conclusion:**The introduction of trauma specific 7F REBOA devices appears to have influenced REBOA practices, with earlier utilization in severely injured hypotensive patients via less invasive means that are associated with lower transfusion requirements and improved survival. Additional study is required to determine optimal REBOA utilization.

## THE IMPACT OF IN-HOSPITAL COMPLICATIONS ON THE LONG-TERM FUNCTIONAL OUTCOMES OF TRAUMA PATIENTS: A MULTICENTER STUDY.

Jae Moo Lee BA, Juan Herrera-Escobar MD, Michel Apoj BA, Syeda Al Rafai MD, MHA, Kelsey Han BA, Deepika Nehra MD, Ali Salim\* MD, Karen Brasel\* MD, MPH, George Kasotakis\* MD, MPH, George Velmahos\* MD, Ph.D., Adil Haider\* MD, MPH, Haytham Kaafarani\* MD, MPH, Massachusetts General Hospital

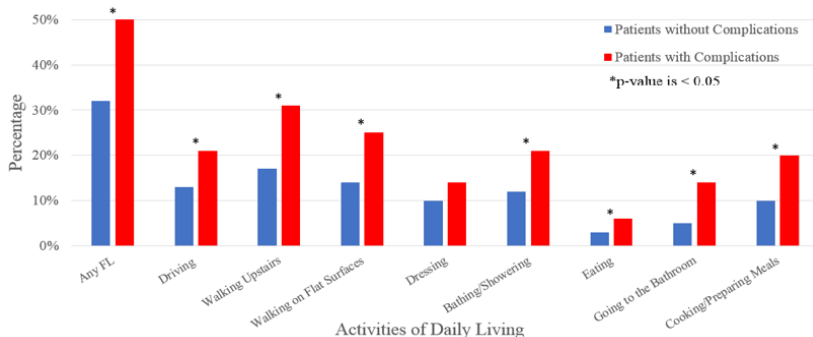
Invited Discussant: David Efron, MD

**Introduction:** The long-term consequences of in-hospital complications in trauma patients remain largely unknown. We sought to study the impact of complications on the long-term functional outcome of trauma patients.

**Methods:** All patients with Injury Severity Score (ISS)  $\geq 9$  admitted to three Level I Trauma Centers between 2015 and 2017 were contacted by phone at 6-12 months post-injury and administered a validated Trauma Quality of Life survey assessing for functional limitation (FL). FL was defined as the inability to independently perform one or more activities of daily living (ADL; e.g. driving, walking on flat surfaces/upstairs, dressing, cooking/preparing meals). The medical records were systematically reviewed for additional demographic/socioeconomic variables, comorbidities, injury mechanism/type/severity and the occurrence of pre-defined in-hospital complications. The impact of complications on FL was assessed using univariate then multivariate logistic regression models.

**Results:** Out of a total of 2511 patients, 1022 patients were included. The mean age was 58 years, 56% were male, 94% had blunt trauma, and the mean ISS was 15. A total of 168 patients (16.4%) had at least one in-hospital complication and reported significantly more FL in most ADLs at 6-12 months, compared to those without complications [Figure]. In multivariable analyses, adjusting for all other variables, the occurrence of an in-hospital complication was associated with a greater likelihood of FL at 6-12 months post-injury [OR = 1.82, 95% CI 1.22-2.69, P = 0.003].

**Conclusion:** Trauma patients with in-hospital complications have worse functional long-term outcome. In addition to primary complication prevention, more rehabilitation resources should be made available to the subgroup of trauma patients who survive complications.



## ARE YOU KIDDING? PEDIATRIC TRAUMA CENTER VERIFICATION IMPROVES OUTCOMES AT AN ADULT CENTER

Sean R. Maloney MD, Eric J. Grossman MD, Ashley B. Christmas\* MD, Kyle W. Cunningham MD, Megan E. Waddell RN, BSN, CPEN, Ronald F. Sing\* DO, Carolinas Medical Center

Invited Discussant: David Margulies, MD

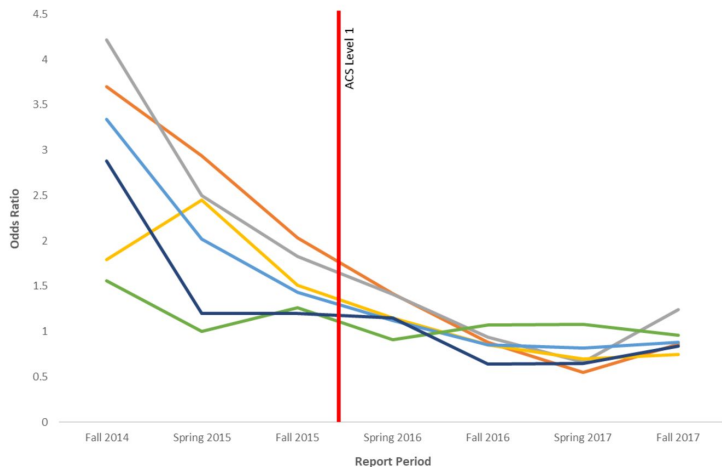
**Introduction:** Trauma continues to be the greatest mortality cause in children. It is known that trauma centers improve outcomes with 103 pediatric trauma centers in the US, of which 54 are level 1. We undertook this study to assess potential outcome improvements associated with the transition from ACS level 2 verification to level 1 status at our pediatric trauma center.

**Methods:** Pediatric trauma patient outcomes were assessed from Fall 2014- Fall 2017. Within this time frame 20 pediatric clinical guidelines were formed. In 2013, our facility added its first Pediatric Trauma Medical Director.

**Results:** For all pediatric patients, the risk adjusted major complication odds ratio (OR) was 2.94 in Spring 2015, decreased to 2.03 in Fall 2015 and decreased to 0.86 in Fall 2017. Including death as a complication yielded a similar trend. Analysis of patients aged 0-13 years showed an OR decrease from Spring 2015 to Fall 2015 to Fall 2017 (2.50 to 1.83 to 1.24). Subgroup analysis of the traumatic brain injury cohort, demonstrated similar results (2.02 vs. 1.43 vs. 0.88). There was also a decrease in median length of stay from 3.0 days to 2.0 days from 2015 to 2017. Pneumonia rates in intubated patients decreased throughout this time period (13.3% to 10.8% to 0.2%) as well as unplanned admission to the ICU (5.2% to 0.8% to 0.4%). Of note, for patients requiring craniotomy, median time to the operating room decreased from 4 hours to 2 hours.

**Conclusion:** During preparation for ACS level 1 pediatric trauma center verification in 2016, our institution noted significant improvements in the outcomes of pediatric trauma patients. Our study is one of the first to look specifically at the improvements in care that are associated with becoming a level 1 pediatric trauma center. Furthermore, these improvements became even more pronounced following the verification process.

Risk Adjusted Major Complications Based on Pediatric TQIP



## TRAUMA OVER-TRIAGE, CONCURRENT TRAUMA ACTIVATION AND OVERLAPPING EGS SURGERY ARE NOT ASSOCIATED WITH SHORT OR LONG TERM MORTALITY IN EGS PATIENTS

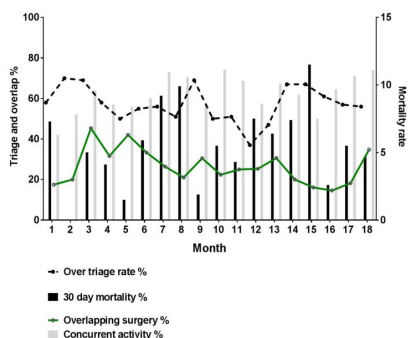
Matthew C. Hernandez MD, Eric J. Finnesgard BA, Johnathon M. Aho MD, Ph.D., Michelle Junker MD, Ariel Knight MD, Brian D. Kim\* MD, Mariela Rivera MD, Daniel Stephens MD, Beth A. Ballinger MD, Donald H. Jenkins\* MD, Martin D. Zielinski\* MD, Henry J. Schiller\* MD, Mayo Clinic - Rochester  
 Invited Discussant: Linda Maerz, MD

**Introduction:** Acute care surgeons manage urgent and emergent tasks that often temporally overlap. Concurrent operations are perceived to impact patient care. However, little is known about the impact of concurrent activities such as trauma activations (TA) with emergency general surgical operations (EGS). We sought to evaluate the frequency and impact of concurrent activity at an institution where a single surgeon takes call for all aspects of acute care surgery at night. We hypothesized that trauma over-triage rates, concurrent activities, and overlapping surgery would affect EGS patient mortality.

**Methods:** A single institutional review of historical data was performed. Trauma and EGS admissions (for January 2016-July 2017) were reviewed. We included adults (>15 years-old for trauma, ≥18 years-old for EGS). All EGS operations and TA during day-time hours (08:00-16:30) were excluded as multiple surgeons would have been present to provide coverage. Patients were categorized as concurrent when a TA (notification to ED discharge) coincided with an EGS operation (incision to closure). EGS overlap was defined as two EGS cases in progress at the same time but the critical portion of the case did not. Baseline demographics, ISS (Injury Severity Score), American Association for the Surgery of Trauma (AAST) EGS grade, American Society of Anesthesiologist (ASA) score, duration of hospitalization, 30-day readmission, 30-day and overall mortality were abstracted. Monthly triage rates were calculated by Cribbari Matrix method, trauma over-triage was considered at >50%. Unadjusted Kaplan-Meier analysis and adjusted Cox proportional hazards models quantified survival.

**Results:** In this study, EGS (n=1135), and TA (n=1324) patients were reviewed. The monthly triage rate ranged from 37 to 70% (median 56%). The overall concurrent activity rate for EGS and TA was 62.5% (n=710). The EGS overlapping surgery rate was 26.5% (n=301). Outcomes in EGS patients with concurrent TA were similar to those without TA with regard to duration of stay (median [IQR]) (2 [0-9] versus 4 [1-11] days, p=0.74), 30-day mortality rates (5.5% versus 5.6%, p=1), and 30-day readmission (49.4% versus 44.9%, p=0.16). Similarly, outcomes in TA patients that coincided with a concurrent EGS case did not differ significantly for duration of stay (4 [2-7] versus 4 [2-8] days, p=0.54), 30-day readmission rates (10.4% versus 8.5%, p=0.88) or thirty-day mortality rates (3.5% versus 3%, p=0.64). In operative EGS patients, factors that were independently associated with thirty-day and one year mortality included AAST EGS grade, ASA, and age but not overlapping EGS surgery, concurrent TA activation, or trauma over-triage rate >50% **Table.**

**Conclusions:** To foster transparency and examine adequate staffing we aimed to define the extent of concurrent and overlapping acute care surgical tasks at night. The rate of concurrent EGS and TA was 62.5% when a single surgeon was covering night call. In this initial analysis, concurrent TA, trauma over-triage (>50%), or overlapping EGS surgeries did not appear to impact thirty day or one-year EGS patient mortality. Conversely, increased patient EGS disease severity, age, and ASA score were associated with short and long term mortality. Prospective study is required to better appraise acute care surgical practices, concurrent activities and their impact on patient specific outcomes.



Cox proportional hazard model of factors associated with thirty-day mortality of EGS patients		
Variable	Risk ratio with 95% CI	P value
Concurrent	1.1 (0.7-1.6)	.7
AAST EGS grade (III, IV, V)	2.7 (1.5-5)	.001
Age (>65 years)	2.8 (1.8-4.6)	.001
ASA class (III, IV, V)	6.7 (2.9-19.5)	.001
Trauma over-triage (>50%)	1.2 (0.7-2)	.4
Overlapping EGS surgery	1 (0.6-1.7)	.7
Cox proportional hazard model of factors associated with one-year mortality of EGS patients		
Variable	Risk ratio with 95% CI	P value
Concurrent	1 (0.6-1.5)	.8
AAST EGS grade (III, IV, V)	2.8 (1.5-5.3)	.001
Age (>65 years)	2.8 (1.8-4.5)	.001
ASA class (III, IV, V)	6.6 (2.8-19.2)	.001
Trauma over-triage (>50%)	1.2 (0.7-2)	.4
Overlapping EGS surgery	1 (0.6-1.6)	.9

## BETA-ADRENERGIC BLOCKADE FOR TREATMENT OF TRAUMATIC BRAIN INJURY: A RANDOMIZED CONTROLLED TRIAL

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Invited Discussant: Bryan Cotton, MD

**Introduction:** Traumatic brain injury (TBI) is a leading cause of death and disability. While options for preventing primary injury are limited, routine interventions preventing secondary injury due to hypoxia and hypotension are within the armamentarium of current critical care. Other successful interventions have been elusive. Catecholamine surges following TBI are proportional to the severity of the underlying TBI. Multiple retrospective, observational studies have shown a benefit of beta-blockade, with propranolol appearing to be the most effective agent. Sufficient data exists to justify testing this intervention in a randomized controlled trial. In this pilot study, we tested the hypothesis that propranolol given within 72 hours to patients with moderate to severe TBI would improve mortality.

**Methods:** A single-center randomized controlled pilot trial was conducted at an urban level-one trauma center from 1/1/16 to 12/31/17. Adult patients with a TBI as determined by GCS<12 on admission and a documented injury on head CT were screened for eligibility. Patients with significant injury in another body region (AIS>3), special populations, and home beta-blocker use were excluded from randomization. Following appropriate informed consent, patients were randomized within 72 hours of injury using block randomization in groups of 4. Patients randomized to the propranolol group (PRO) were started on propranolol 20 mg TID and titrated up by 60 mg/day until heart rate was less than 100. The control group was managed according to institutional standards based on the Brain Trauma Foundation Guidelines. Medication duration was 14 days and patients were followed until death or discharge. Demographics, physiologic variables, severity of injury, LOS, urinary catecholamines, and mortality were compared between groups. Primary outcome was mortality and secondary outcome was effect on urinary catecholamines. Statistical analysis was performed using Student's t test or Wilcoxon Rank Sum test based on distribution. Chi-square or Fisher's exact test was used for categorical variables where appropriate. A nested factorial mixed model ANOVA with repeated measures was used to estimate differences between treatment arms over time. The trial is registered on [clinicaltrials.gov](http://clinicaltrials.gov).

**Results:** Over the 24-month study period, 525 patients were screened and 26 were randomized. One patient was excluded after randomization due to home beta-blocker use. At randomization, the groups were comparable with no differences in demographics or clinical variables (table). The PRO group had a longer hospital LOS ( $p=0.024$ ), but no difference was found in ICU LOS. Mortality was lower in the PRO group (7.7% vs 36.4%), but this difference did not reach significance. Several differences were found in heart rate, temperature, mean arterial pressure, and ICP on a daily basis both *between* and *within groups*. No overall differences were detected for heart rate ( $p=0.143$ ), temperature ( $p=0.339$ ), or ICP (0.141). Mean arterial pressure was significantly higher in the PRO group as compared to the control ( $p=0.021$ ). No overall treatment effect was noted for GCS ( $p=0.419$ ), but day 14 GCS was significantly higher in the PRO group (11.7 vs. 8.9;  $p=0.044$ ). No differences were found in the levels of urinary catecholamines over the study period. Despite not being different at the traditional significance level, all daily urinary catecholamines were higher in the PRO group from study day 2 to the end of the study.

**Conclusion:** This trial protocol is safe and feasible in the TBI population. While not powered to detect differences between groups, the PRO group had a higher mean arterial pressure and GCS was significantly better at the end of study despite no difference in mortality. A larger multi-center trial is needed to validate these initial results and increase the power to detect clinically meaningful differences between the treatment arms.

	PRO n=13	Control n=12	p
Age (Years)	49.7 (±19.0)	53.0 (±21.9)	0.689
Female	36.0%	41.7%	0.688
Blunt	88.0%	91.7%	0.999
ISS	21.9 (±4.2)	21.8 (±5.5)	0.965
Head AIS	3 (3,4)	4 (3,4)	0.611
Charlson Index	1 (0,2)	2 (0.5, 3.5)	0.351
24-Hr Transfusions	0 (0,2)	0 (0,0)	0.389
Base Deficit (meq/L)	-4.8 (±2.6)	-2.4 (±4.7)	0.132
Lactate (mmol/L)	2.2 (±1.3)	2.8 (±2.1)	0.371
LOS (Days)	31 (±12)	20 (±10)	0.024
ICU LOS (Days)	16 (±7)	16 (±7)	0.821
Mortality	7.7%	36.4%	0.142



## **Physiologic impact of XSTAT 30 use in the management of non-compressible torso hemorrhage**

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Oregon Health & Science University

Invited Discussant: Kyle Remick, MD

**Introduction:** Non-Compressible Torso Hemorrhage (NCTH) remains one of the leading causes of death in both civilian and military pre-hospital care. Novel techniques for management of NCTH like REBOA, selective aortic arch perfusion (SAAP) and the Abdominal Aortic Junctional Tourniquet-Torso Plate, have high potential for significant co-morbidities including ischemia-reperfusion injury when applied in the prolonged field care paradigm. One promising avenue for control of abdominal NCTH is through the novel use of RevMedx XSTAT 30 (an FDA approved sponge-based dressing utilized for extremity wounds). We hypothesized that XSTAT would effectively mitigate uncontrolled NCTH during a prolonged pre-hospital period with correctable physiologic dyshomeostasis following damage control surgery (DCS), resuscitation and critical care. In addition we examined the incidence of intra-cavitary pellets remaining following DCS prior to definitive closure by radiologic investigation.

**Methods:** Twenty-four male swine (53±2kg) were anesthetized, underwent line placement for monitoring, laparotomy and splenectomy. Animals then underwent laparoscopic transection of 70% of the left lobe of the liver and were allowed to hemorrhage freely for a period of 10 minutes. They were then randomized into three groups: Hextend (Hex), Free Pellets (FP), and Bagged Pellets (BP). The animals were observed for a pre-hospital period of 180 minutes. At 180 minutes the surviving animals underwent DCS, balanced blood product resuscitation and removal of pellets followed by an ICU period of 5 hours with pre-defined parameters for clinical intervention and care. Postoperative fluoroscopy was performed to identify pellets or bags not recovered during DCS.

**Results:** Baseline physiologic and injury characteristics were not different. Survival rates were significantly higher in FP and BP ( $p < 0.01$ ) vs Hex. DCS duration was significantly longer in FP in comparison to BP ( $p = 0.001$ ). There were two animals in the FP group with pellets discovered on fluoroscopy following DCS in comparison to zero in the BP group. There was no significant difference in blood product administration or pressor requirements between groups. End ICU lactates trended to baseline in both FP and BP groups.

**Conclusion:** In the setting of abdominal hemorrhage, XSTAT may be a viable intervention to address NCTH in pre-hospital care as demonstrated by improved survival in comparison to fluid resuscitation alone without secondary consequences of critical metabolic dyshomeostasis. XSTAT can be easily identified and removed prior to definitive abdominal closure.

## PERCENT CHANGE FROM PRE-INJURY BLOOD PRESSURE IS AN INDEPENDENT PREDICTOR OF MORTALITY IN ELDERLY TRAUMA

Savo Bou Zein Eddine MD, Kelly A. Boyle MD, Christopher M. Dodgion MBA,MD, MSPH, Colleen Trevino Ph.D.,RN, FNP, Jeremy S. Juern\* MD, Thomas W. Carver\* MD, Christopher S. Davis MD,MPH, David J. Milia MD, Panna A. Codner\* MD, Jacob R. Peschman MD, Travis P. Webb\* MD, MHPE, Marc A. De Moya\* MD, Medical College of Wisconsin

Invited Discussant: Jennifer Hubbard, MD

**Introduction:** The correlation between baseline blood pressure and outcomes has been poorly studied. We hypothesize that a decrease from baseline (preinjury) systolic blood pressure (SBP) is an independent predictor of mortality among elderly trauma patients.

**Methods:** The 2010 to 2017 trauma registry at a Level 1 Trauma Center was linked to the electronic health records to identify patients aged  $\geq 65$  years old with available baseline SBP. Baseline SBP (bSBP) was defined as the average of the last 3 SBP measurements recorded within 2 years of the trauma date in an ambulatory clinic or an outpatient setting.

Trauma SBP (tSBP) was defined as the first SBP reading in the Emergency department after presentation for trauma. Delta SBP (dSBP) was defined as the percent change of

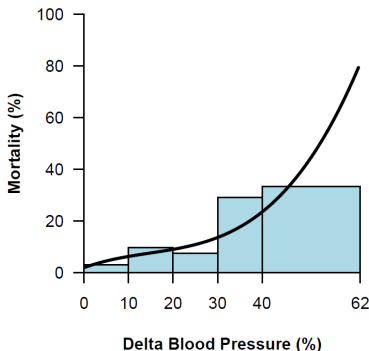
tSBP from bSBP. Univariate and logistic multivariate regression analysis were constructed to assess the independent impact of the bSBP and the change from bSBP on mortality controlled for demographics, comorbidities, injury mechanism/severity. **Results:**

A total of 2059 patients met our inclusion criteria with a mean age of 79.8 years (65.0 -102.0,  $\pm 8.4$ ) and mean bSBP of 131.3 mmHg (75.3 – 209.0,  $\pm 17.5$ ). Mortality was 5.0% in this cohort. Of these patients, 533 (25.9%) had a decrease in tSBP from their bSBP (or dSBP $>0$ ) on presentation to the emergency department.

In the unadjusted analysis, sex ( $p < 0.001$ ), Glasgow Coma Scale (GCS) ( $p < 0.001$ ), Injury Severity Score (ISS) ( $p < 0.001$ ), mechanism of injury ( $p < 0.001$ ), tSBP ( $p < 0.002$ ), and dSBP ( $p < 0.001$ ) were significant predictors of mortality.

In the multivariate analyses, 10% change from bSBP [OR= 1.39, (95% CI: 1.02, 1.90)] and male sex [OR=3.45, (95% CI: 1.49, 8.01)] were significant predictors of mortality. GCS 13-15 [OR=0.03, (95% CI: 0.01, 0.07)] was a protective factor. Mortality exponentially increased after a 20% decrease of blood pressure or more from bSBP.

**Conclusion:** A decrease from baseline preinjury SBP by 10% or more is an independent predictor of mortality in the elderly trauma patient.



## THE NLRP3 INFLAMMASOME PATHWAY LEADS TO THE LOSS OF BLOOD-BRAIN BARRIER INTEGRITY IN TRAUMATIC BRAIN INJURY

Bobby D. Robinson MD, Chinchusha Anasooya Shaji BS, Claire L. Isbell MD, Stanley Kurek\* Jr., DO, Justin Regner MD, Binu Tharakan Ph.D., Baylor Scott And White Medical Center - Temple

Invited Discussant: Mayur Patel, MD, MPH

**Introduction:** The integrity of the blood-brain barrier (BBB) is critical in limiting vasogenic cerebral edema following traumatic brain injury (TBI). The proinflammatory cytokine interleukin 1 $\beta$  (IL-1 $\beta$ ) is a critical mediator of BBB breakdown following TBI. The NLRP3 inflammasome pathway activated in TBI regulates IL-1 $\beta$  secretion. We hypothesized that the activation of this pathway is critical to BBB breakdown and hyperpermeability resulting in cerebral edema following TBI.

**Method:** *In vitro* studies consisted of immunofluorescence of tight junction-associated proteins and monolayer permeability for evaluating barrier function. Rat brain microvascular endothelial cells (BMECs) were treated with chitosan, an NLRP3 inflammasome activator. The tight junction protein zonula occludens-1 (ZO-1) and adherens junction protein  $\beta$ -catenin were localized. Human BMECs were grown as a monolayer on Transwell plates; permeability was induced with chitosan, and transendothelial electrical resistance (TEER) was performed to evaluate barrier function. *In vivo* studies utilized a mouse controlled cortical impact model of moderate TBI in C57/BL6 mice. Sham mice had craniectomy only (n=5/group). Chitosan and inhibitors (NLRP3 inhibitor MCC950 and caspase-1 inhibitor Ac-YVAD-cmk) were administered 10 minutes after injury (n=5/group). Intravital microscopy imaging of the pial venules was performed for up to 70 minutes after injury. The difference in fluorescence intensity between the intravascular space and interstitium ( $\Delta$ ) was measured and represented BBB hyperpermeability.

**Results:** Junctional localization of ZO-1 and  $\beta$ -catenin showed decreased integrity when treated with chitosan *in vitro*. Chitosan administration led to a decrease in the TEER in human BMECs ( $p < 0.05$ ). TBI resulted in significant increase in BBB permeability when compared to sham group ( $p < 0.05$ ). Chitosan administration led to BBB hyperpermeability compared to control group ( $p < 0.05$ ) *in vivo*. Treatment with the caspase-1 and NLRP3 inhibitors significantly decreased BBB hyperpermeability after TBI ( $p < 0.05$ ).

**Conclusion:** Activation of the NLRP3 inflammasome pathway leads to BBB breakdown/microvascular hyperpermeability *in vitro* and *in vivo*, and specific pathway inhibitors mitigates these effects.

## OBESITY IS NOT ASSOCIATED WITH MICROVASCULAR INFLAMMATION FOLLOWING INJURY

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Invited Discussant: Carlos Brown, MD

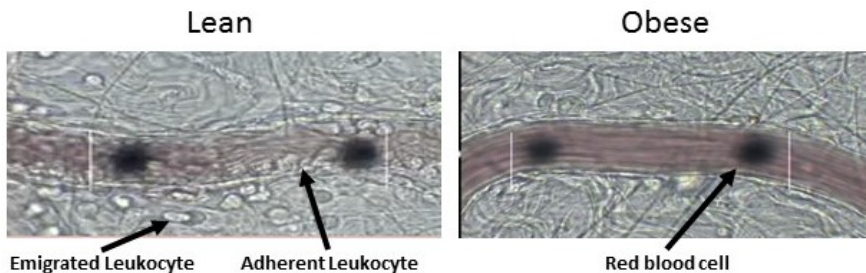
**Introduction:** Obesity is associated with organ failure and thromboembolic events following injury. Prior work has demonstrated that although obesity is associated with a pro-inflammatory state in the uninjured, the obese show relative immune suppression following major trauma. Furthermore, although obesity is clearly linked to hypercoagulability, circulating markers with pro-inflammatory and procoagulant properties are not elevated following trauma while simultaneously showing greater expression in adipose tissue. This dichotomy suggests a possible adipose-mediated perivascular effect that might explain an increased propensity for thrombosis in the obese. We hypothesized that we would see evidence of enhanced microvascular inflammation in obese subjects following injury.

**Methods:** Sprague-Dawley rats were divided into groups in which they were fed either a standard diet or high-fat, high calorie diet for eight weeks. To create injury, the backs of experimental subjects were exposed to steam for one minute while controls were not exposed to steam. Leukocyte adherence (LA) in mesenteric venules of anesthetized experimental and control subjects was measured using intravital microscopy. Adherent leukocytes were defined as those that remained stationary to the venular wall for at least 30 seconds, and expressed as number per 100  $\mu\text{m}$  venular length.

**Results:** Obese subjects weighed significantly more than lean at the time of injury ( $452 \pm 16.3$  vs.  $366 \pm 12.7$  grams,  $p < 0.05$ ). In subjects fed standard diet, LA increased four hours after burn ( $16.2 \pm 2.2$  vs  $1.4 \pm 0.3$  per 100  $\mu\text{m}$  at 0 minutes,  $p < 0.05$ ,  $n=7$ ), but not in controls ( $2.3 \pm 0.3$  vs  $1.5 \pm 0.3$  per 100  $\mu\text{m}$  at 0 minutes,  $n=7$ ). At four hours after burn, lean subjects showed a significant increase in leukocyte adherence over obese subjects ( $12.9 \pm 2.6$  vs  $3.1 \pm 0.3$  per 100  $\mu\text{m}$ ,  $p < 0.05$ ), with the obese showing limited evidence of leukocyte adherence and emigration at four hours following injury. Figure 1 shows representative photographs of the microcirculation 4 hours after burn in lean and obese subjects.

**Conclusion:** While burn injury led to microvascular inflammation in lean subjects, there was minimal inflammation in the mesenteric microvasculature of the obese. This is consistent with previous work demonstrating that obesity in the setting of trauma leads to a state of relative immune suppression. These data do not support the notion that adipose-mediated perivascular inflammation is a causative factor for increased thromboembolic phenomena in the obese following injury.

Figure 1. Leukocyte adherence in mesenteric venules four hours following burn injury



## THE DIVERSITY OF SURGICAL CRITICAL CARE: A REPORT OF THE TRAUMA ICU PREVALENCE PROJECT (TRIPP), AN AAST MULTI-INSTITUTIONAL STUDY

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Invited Discussant: Panna Codner, MD

**Introduction:** Surgical Critical Care is crucial to the care of trauma and surgical patients. This study was designed to provide a contemporary assessment of patient types, injuries, and conditions in ICUs caring for trauma patients to inform the design of processes of care to meet patient needs.

**Methods:** This was a 1-day, multicenter prevalence study where participants supplied data on all patients in their TICU (ICU where majority of critical trauma patients were admitted) on 11/2/17 and their 30-day outcomes.

**Results:** 27 Level I and 3 Level II trauma centers across the U.S. entered 501 pts classified as: 244 (48%) trauma, 167 (33%) non-trauma surgical, 90 (18%) medical. The most prevalent injuries, surgical conditions, ICU diagnoses, and operations are shown in the Table. 360 patients (72%) underwent surgery, 5.7% had an open abdomen. 163 (33%) had an infection: 51(10%) intra-abdominal, 43(8.5%) ventilator-associated pneumonia, 32 (6.3%) soft tissue, and 28 (5.5%) other pneumonia. 278 (55%) were on antibiotics, and 51 (10%) on antifungal agents. 338 (67%) had been intubated, with 46% currently on a ventilator. 95 (19%) had a tracheostomy (performed after a median 8 days [IQR 5-12] of intubation). Arterial and central lines were each present in >36% of patients: 62.6% had a urinary catheter. 15% of patients were on vasoactive infusions and 64 (12.8%) were on both vasoactive drugs and a ventilator. 14.5% were comatose and 36 (7.1%) had intracranial pressure monitors. Altered mental status (46%) and enteral opioid use (47%) were common. 20% of patients had a transfusion within the last 24 hours. 30-day follow-up data were available for 440 patients (88%). 12 were still in the ICU, median ICU days were 10 [4-19] and hospital days were 17 [9-31]. Mortality was 13% (n=57).

Injuries	n (%)	ICU conditions	n (%)
Brain	102 (41.8%)	Respiratory failure	244 (48.7%)
Rib fracture	101 (41.4%)	Acute anemia	141 (28.1%)
Pneumo/hemothorax	76 (31.1%)	Sepsis	82 (16.3%)
Facial fracture	59 (24.1%)	Delirium	79 (15.7%)
Leg fracture	50 (20.4%)	Acute kidney inj.	76 (15.1%)
<b>Non-trauma surgical conditions</b>		<b>Operations</b>	
Abdominal	56 (33.5%)	Abdominal	122 (24.3%)
Other Gen Surgery	34 (20.3%)	Extremity ortho.	63 (12.5%)
Neurological	22 (13.1%)	Vascular	53 (10.5%)
Vascular	21 (12.5%)	Soft tissue	45 (9.9%)
Transplant	11 (6.5%)	Spine	44 (8.7%)

**Conclusion:** Acuity of trauma ICUs in the U.S. is very high, as is the breadth of pathology and the interventions provided. Further assessment of the global predictors of outcome is needed to inform the education, research, clinical practice, and staffing of surgical critical care providers.

**TEACHING HOW TO STOP THE BLEED: DOES IT WORK? A PROSPECTIVE EVALUATION OF TOURNIQUET APPLICATION IN SECURITY AND LAW ENFORCEMENT PERSONNEL**

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Invited Discussant: Babak Sarani, MD

**Introduction:** In October 2015, the “Stop the Bleed (STB)” program, the brain child for Dr. Lenworth Jacobs, was launched by the White House as a call to action for the use of bleeding control techniques by persons at the scene of traumatic injury. With death possible within 5 minutes of injury from a major vascular trauma, prompt control of hemorrhage is key. Wartime data from 2000’s demonstrated that the correct tourniquet use has a mortality benefit of 13-51% while incorrect application was associated with lesser reduction in mortality. Studies have shown that proper education leads to individuals becoming more apt to use tourniquets in the field. The purpose of this study was to conduct a pre and post evaluation of the STB course in a group of private security and law enforcement personnel.

**Methods:** A pre and post questionnaire using the Likert scale was shared with law enforcement and security personnel on their knowledge and comfort level with the use of tourniquets. Participants were also observed while placing tourniquets and the time for placement recorded. The didactic portion and practical session of the STB was then taught and participants were again observed placing tourniquets and a clean copy of the questionnaire distributed. Fisher's Exact tests or Wilcoxon matched-pairs signed-ranks tests were used, as appropriate, to compare pre-post measurements.

**Results:** A total of 54 subjects were enrolled over the course of three sessions. The tourniquet was applied correctly by 14.5% (8/54) and 92.6% (50/54) of enrollees at the pre- and post-instruction assessments, respectively ( $p < 0.001$ ). Mean times to apply the tourniquet were  $28.4 \pm 11.9$  and  $19.5 \pm 6.6$  min, respectively ( $p < 0.001$ ). Subjects reported their level of comfort with the tourniquet to be  $5.7 \pm 3.2$  and  $8.9 \pm 2.0$ , respectively ( $p < 0.001$ ) and their familiarity with anatomy and bleeding control to be  $5.6 \pm 3.3$  and  $8.1 \pm 2.3$ , respectively ( $p < 0.001$ ). At the end of the course, the mean score in response to a question about the extent to which the explanation had helped was  $8.8 \pm 2.1$  (95% CI: 8.2 to 9.4) and to a question about the extent to which teaching would make them feel more secure and safe was  $8.8 \pm 2.3$  (95% CI: 8.2 to 9.4).

**Conclusion:** The teaching of STB improved the correct placement of tourniquets and demonstrated dramatic improvements in application time. Moreover, participants reported increased levels of comfort with addressing active bleeding and found the course to be invaluable. These findings illustrate the importance of the STB program and validate the need for ongoing education.

## **WHEN IS IT SAFE TO START VTE PROPHYLAXIS AFTER BLUNT SOLID ORGAN INJURY? A PROSPECTIVE STUDY FROM A LEVEL I TRAUMA CENTER**

Morgan Schellenberg MD,MPH, Kenji Inaba\* MD, Patrick Heindel BS, Elizabeth Benjamin\* MD,Ph.D., Aaron Strumwasser MD, Kazuhide Matsushima MD, Lydia Lam\* MD, Demetrios Demetriades\* MD,Ph.D., LAC+USC Medical Center

Invited Discussant: Forrest Fernandez, MD

**Introduction:** The optimal timing of venous thromboembolism (VTE) prophylaxis initiation after blunt solid organ injury is controversial. Trauma patients are known to be at high risk for VTE, but competing concerns about bleeding exist in patients with blunt solid organ injuries. Retrospective studies suggest initiation within 48 hours is safe. This study was designed to prospectively study the timing of VTE prophylaxis initiation among patients managed nonoperatively after blunt solid organ injury in order to determine the optimal window for initiation of VTE prophylaxis.

**Methods:** All patients presenting to our Level I trauma center after blunt trauma over a 1 year period (12/01/16 to 11/30/17) were prospectively screened for inclusion in this observational study. Patients were included if a solid organ injury (liver, spleen, and/or kidney) was diagnosed on the initial CT scan and a plan was made for nonoperative management. Patients were excluded if they were transferred to or from an outside hospital, managed operatively from the outset, or on home anticoagulation. Angioembolization was not an exclusion criterion. Demographics, injury and clinical data, type and timing of initiation of VTE prophylaxis, and outcomes (need for blood transfusion, need for delayed IR or OR intervention, hospital LOS, ICU LOS, mortality, and complications including DVT and PE) were collected. The decision to initiate VTE prophylaxis was at the discretion of the attending surgeon. Outcomes were compared between patients who underwent VTE prophylaxis initiation  $\leq 48$  hours vs  $>48$  hours after hospital admission.

**Results:** After applying exclusion criteria, 198 patients were identified over the 1 year study period who sustained a blunt solid organ injury managed nonoperatively. Mean age was 40 years (range 16-92) and 65% of patients were male (n=129). Liver injuries were most common (n=104, 52%), followed by spleen (n=78, 39%) and kidney (n=45, 23%). Mean grade of injury was 3 (range 1-5) for liver, 2 (range 1-5) for spleen, and 3 (range 1-5) for kidney. Mean time of initiation of VTE prophylaxis was 69 hours after admission. As compared to patients who were initiated on VTE prophylaxis  $>48$  hours after admission (n=88, 45%), patients who were initiated  $\leq 48$  hours (n=109, 55%) had fewer DVTs (0 vs 9, p=0.006) and VTEs (2 vs 15, p=0.004) but similar numbers of PEs (2 vs 6, p=0.254). No patients in either group required delayed IR or OR for bleeding after initiation of VTE prophylaxis.

**Conclusion:** In this prospective observational study of patients with blunt solid organ injuries managed nonoperatively, early ( $\leq 48$ h) initiation of VTE prophylaxis resulted in a lower incidence of VTE without an associated increase in the risk of bleeding or need for operative intervention or angioembolization. Early initiation of VTE prophylaxis is therefore likely to be beneficial for patients with blunt solid organ injury. A prospective multicenter trial should be performed to validate these findings.

## THROMBOPROPHYLAXIS WITH NOVEL ORAL ANTICOAGULANTS IS ASSOCIATED WITH LOWER VENOUS THROMBOEMBOLIC EVENTS IN OPERATIVE SPINE TRAUMA

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Invited Discussant: Mark Cipolle, MD, PhD

**Introduction:** Patients with spinal trauma are at high-risk for venous-thromboembolism (VTE). The use of novel oral anticoagulants (NOACs) for thromboprophylaxis is becoming more prevalent after elective orthopedic procedures. However, there is a paucity of data regarding the use of NOACs in trauma patients. The aim of our study was to assess the impact of NOACs vs low molecular weight heparin (LMWH) for thromboprophylaxis in patients with operative spinal trauma.

**Methods:** A 2-year (2015-16) review of patients with isolated spine trauma (S-AIS $\geq$ 3 and other region-AIS $<$ 3) who underwent operative intervention and received LMWH or NOACs for thromboprophylaxis. Patients were stratified into two groups based on the type of thromboprophylaxis: NOACs and LMWH; and were matched in a 1:2 ratio using propensity-score-matching for demographics, admission vitals, injury parameters, type of operative intervention, hospital stay, and timing of initiation of thromboprophylaxis. Outcomes were rates of DVT and/or PE, pRBCs transfusion, the rate of operative interventions for spinal cord decompression and mortality after initiation of thromboprophylaxis.

**Results:** A total of 6036 patients had isolated spine trauma and underwent operative intervention, of which 810 patients (NOACs: 270; LMWH: 540) were matched. Mean age was 50 $\pm$ 20y, 64% were males, and median ISS was 14 [9-18]. Matched groups were similar in demographics, injury parameters, ED-Vitals, hospital stay, rates of IVC filter placement and timing of initiation of thromboprophylaxis. The overall rate of DVT was 5.6%, PE was 1.6, and mortality was 2.5%. Patients who received NOACs, were less likely to develop DVT (1.8% vs 7.4%,  $p<$ 0.01) and PE (0.3% vs 2.1%,  $p=$ 0.04). There was no difference in post-prophylaxis pRBCs transfusion requirements ( $p=$ 0.76), post-prophylaxis decompressive procedure on the spinal cord ( $p=$ 0.49), and mortality ( $p=$ 0.48).

**Conclusion:** In patients with operative spine trauma, thromboprophylaxis with novel oral anticoagulants is associated with lower rates of DVT and PE. NOACs can be considered as an alternative to reduce the risk of VTE in this high-risk patient population. Further prospective clinical trials should evaluate the role of NOACs in preventing VTE events.

Table 2. Primary and Secondary outcome measures of the study

Variables	NOACs (n=270)	LMWH (n=540)	P-value
<b>Primary</b>			
DVT, % (n)	1.8% (5)	7.4% (40)	<0.01
PE, % (n)	0.3% (1)	2.1% (12)	0.04
<b>Secondary</b>			
Post-prophylaxis pRBCs transfusions received, % (n)	1.8% (5)	1.4% (8)	0.76
Post-prophylaxis decompression of spinal cord, % (n)	1.5% (4)	0.9% (5)	0.49
Mortality, % (n)	1.8% (5)	2.7% (15)	0.48

DVT = Deep Venous Thrombosis, PE = Pulmonary Embolism, pRBCs= Packed Red Blood Cells



## AMERICAN FIREARM HOMICIDES: THE IMPACT OF YOUR NEIGHBORS

Erik J. Olson MD, Mark Hoofnagle MD, Elinore Kaufman MD, Patrick M. Reilly\* MD,  
Mark J. Seamon\* MD, University of Pennsylvania

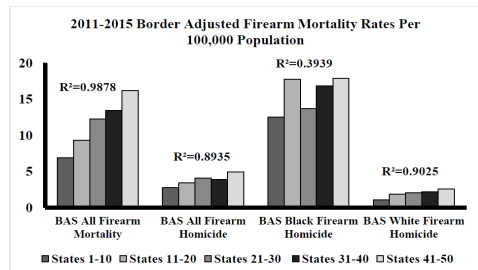
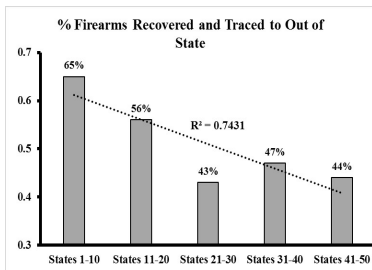
Invited Discussant: Carnell Cooper, MD

**Introduction:** Previous reports demonstrated that restrictive state firearm legislation correlated with decreased overall, white, suicide, and pediatric firearm fatality rates (FFR) but did not correlate with homicide or black FFR. We hypothesized that firearm trafficking from less restrictive neighboring states influences firearm homicide rates, making individual state firearm laws less effective.

**Methods:** For the years 2011-2015, state firearm legislation Brady Campaign to Prevent Gun Violence scorecards were analyzed in relation to firearms traced to specific states by the Bureau of Alcohol, Tobacco, Firearms and Explosives (ATF) and reported Center for Disease Control and Prevention FFR (WISQARS). All states were then ranked by Brady score (Normalized Brady Score [NBS]) and arranged by quintile. The effect of less-restrictive neighboring states on the 10 most-restrictive firearm legislation states was modeled by averaging the 10 most-restrictive states with their bordering states. All states were then re-ranked based on the new Border Adjustment Score (BAS). FFR were calculated for each quintile and Poisson regression models were created for each score and outcome. Model fit was compared using Aikake information criterion (AIC).

**Results:** From 2011-2015, there were 169,396 total firearm fatalities including 57,885 firearm homicides (33,158 black, 23,158 white homicides). When top and bottom quintile states for firearm legislation were compared, 65% vs 44% of firearms traced by ATF originated in other states respectively (Figure, % Firearms Recovered). The BAS had a more linear relationship with the overall FFR, all firearm homicide, and both black and white firearm homicide as gun legislation BAS decreased (Figure, 2011-2015 Border Adjusted). The BAS minimized the AIC with respect to the NBS for black homicide (AIC 4443 vs. 4680) and white homicide (3243 vs. 4319), indicating improved model fit after adjustment for neighboring state firearm legislation.

**Conclusion:** Our results suggest that firearm movement across state borders plays an important role in firearm homicides. Accounting for firearm legislation in both individual and neighboring states may improve our understanding of the relationship between firearm legislation, homicide and race.



## IMPACT OF LICENSED FEDERAL FIREARM SUPPLIERS ON FIREARM-RELATED MORTALITY

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Invited Discussant: Henry Schiller, MD

**Introduction:** Legal firearm sales occur largely through suppliers that have Federal Firearm Licensees (FFLs). These include a wide range of distributors, such as gun stores and pawnshops. Since FFL density might reflect ease-of-access to firearm purchases, we hypothesized that the number of FFL dealers would be associated with firearm-related deaths. We further hypothesized that licensee-type subsets would be associated with differential risks for gun-related deaths.

**Methods:** We used data from the National Center for Health Statistics National Vital Statistics System (2008-2014) and national data on Federal Firearms Licensees available through the Bureau of Alcohol, Tobacco, Firearms and Explosives for 2014. FFL density was determined by normalizing FLL license number by population. Correlation analysis and linear regression analysis were performed to determine the relationship between different licensee types and firearm-related deaths. We controlled for population, number of statewide registered firearms, and the density of other types of FFLs.

**Results:** We identified a total of 65,297 FFLs in 2014. There was a moderate correlation ( $R = 0.53$ ,  $\rho = 0.48$ ) between total FFL density and firearm-related death rates. Further analysis by type of firearm-related death showed a strong correlation ( $R = 0.81$ ,  $\rho = 0.76$ ) between total FFL density and firearm-related suicide rates. No correlation was found between total FFL density and firearm-related homicide rate.

Among individual FFL types, FFL02 (firearm dealing pawnshop) density was the only FFL-type found to be correlated with

firearm-related death rates. We found a strong correlation between FFL02 density and overall firearm-related death rate ( $R = 0.69$ ,  $\rho = 0.78$ ) and firearm-related suicide rate ( $R = 0.72$ ,  $\rho = 0.78$ ) (Figure 1).

Linear regression analysis showed that even while controlling for number of registered firearms and population, the number of

firearm-dealing pawnshops remained significantly associated with overall firearm-related deaths and firearm-related suicides. Linear regression results show an incremental 4.23 gun-related deaths for each additional firearm-dealing pawnbroker per state over the study period.

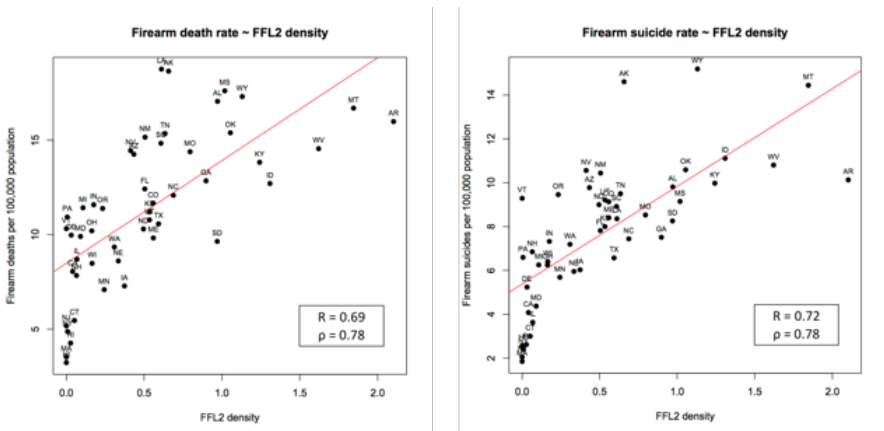


Figure 1: Firearm dealing pawnshop density vs. Firearm death rate and Firearm suicide rate

**Conclusion:** Access to legally-distributed firearms is associated with firearm-related death rates, particularly firearm-related suicides. There was no association with firearm-related homicides. Furthermore, firearm-dealing pawn shops were associated with suicide-related deaths. These findings suggest that deeper exploration of legal firearm access and firearm-related injuries would benefit discussion of preventative measures.