

**PREHOSPITAL WHOLE BLOOD IS ASSOCIATED WITH  
IMPROVED HEMOSTASIS AND CLINICAL OUTCOMES:**

**RESULTS OF A PROSPECTIVE RANDOMIZED PILOT TRIAL**

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Invited Discussant: Donald Jenkins, MD

**Introduction:** Whole Blood (WB) resuscitation is increasingly common in both military and civilian settings. Data regarding the safety and efficacy of prehospital WB remains limited.

**Methods:** We performed a prospective cluster randomized prehospital thru in-hospital whole blood pilot trial for injured air medical patients. We compared standard prehospital air medical care including red cell transfusion and in-hospital component transfusion to WB resuscitation. Prehospital vital signs were used as inclusion criteria ( $SBP \leq 90$ ;  $HR \geq 108$ ) or ( $SBP \leq 70$ ) for patients at risk of hemorrhage. Primary outcomes were feasibility and 28-day mortality. Secondary outcomes included 24hr mortality, multiple organ failure, nosocomial infection, 24hr transfusion requirements and arrival coagulation parameters.

**Results:** Between November 2018 thru October 2020, 86 injured patients were cluster randomized by helicopter base. Overall, 28-day mortality for the cohort was 26%. Injured patients randomized to prehospital whole blood ( $n=40$ ) relative to standard care ( $n=46$ ) were similar in demographics, injury characteristics, shock severity and incidence of brain injury. Intent to treat Kaplan-Meier survival analysis demonstrated no statistical mortality benefit at 28 days (25% vs. 26%, log rank 0.03,  $p=0.80$ ) Patients randomized to prehospital WB relative to standard care had lower blood component transfusion requirements at 24 hours ( $p=0.04$ ) and improved arrival thromboelastography parameters (K-time, maximal amplitude and G-value, all  $p<0.05$ ) compared to standard care patients. WB randomized patients demonstrated a trend toward a lower incidence of nosocomial infection ( $p=0.07$ ) and improved INR upon arrival ( $p=0.08$ ). Multivariable regression analysis demonstrated a significant 24-hour mortality benefit (OR 0.10 95%CI 0.01-0.97,  $p=0.048$ , FIGURE) after controlling for differences in prehospital resuscitation and injury characteristics. No transfusion reactions during the prehospital or in-hospital phase of care were documented.

**Conclusion:** Prehospital thru in-hospital WB resuscitation is safe and associated with hemostatic and clinical outcome benefits. A large-scale clinical trial is feasible and would allow the effects of WB on survival and other pertinent clinical outcomes to be appropriately characterized.

## **LIFE OVER LIMB: VASCULAR LIMB COMPLICATIONS FOLLOWING REBOA**

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Invited Discussant: Jeffrey Nicholas, MD

**Introduction:** Vascular limb complications (VLC) may complicate the arterial access required for resuscitative endovascular balloon occlusion of the aorta (REBOA) access and may be a source of morbidity. We sought to identify and characterize the occurrence of VLC in REBOA survivors.

**Methods:** This is a retrospective cohort study of adult patients (2013-2020) from the AAST Aortic Occlusion for Resuscitation in Trauma and Acute care surgery registry who underwent REBOA and survived at least 48 hours. The primary outcome was VLC, (clinically apparent extremity ischemia or distal embolization). Demographics, injury severity, and presenting and procedural characteristics were compared between patients with and without VLC.

**Results:** Of 418 identified patients, 36 (8.6%) had at least one recorded VLC: 22 ischemia, 25 embolism, 11 both. Demographics and injury severity and characteristics were similar between those with and without VLC. SBP at placement was modestly lower in those with VLC ( $62 \pm 29$  vs  $70 \pm 35$  mmHg,  $P=.09$ ); median time arrival to REBOA was 20 min in both groups. VLC was associated with larger devices (7.3% VLC with ER-REBOA vs 22% other,  $P=.009$ ), arterial access technique (25% cutdown, 8.4% percutaneous,  $P=.02$ ), procedural setting (11% ER vs 4.9% other,  $P=.05$ ), pelvic binder/ex-fix (14% vs 6.4%,  $P=.01$ ), and strongly associated with TXA use (14% vs 5.3%,  $P=.002$ ). 61% of VLC had TXA administered. Mortality was 22% and not associated with VLC, however VLC had longer hospital length of stay (LOS, 31 vs 24 days,  $P=.02$ ). 5 VLC had recorded surgical intervention, 4 underwent amputation. On multivariate analysis, cutdown technique (OR 3.4, 95%CI 2.9-3.9,  $P=.02$ ) and TXA (2.7, 2.3-3.1,  $P=.006$ ) independently predicted VLC.

**Conclusion:** Vascular limb complications occur in at least 9% of REBOA survivors and result in prolonged LOS and still undefined morbidity. TXA should be used with caution in patients undergoing REBOA and the percutaneous technique for placement is preferred.

## BALLOONS FOR KIDS: ANATOMIC CANDIDACY AND OPTIMAL CATHETER SIZE FOR PEDIATRIC REBOA

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Invited Discussant: Barbara Gaines, MD

**Introduction:** REBOA (Resuscitative Endovascular Balloon Occlusion of the Aorta) is a potential adjunct in pediatric trauma patients with truncal hemorrhage, however there is little data evaluating the anatomic considerations of REBOA in children. We evaluated the vascular dimensions and anatomic limitations of utilizing REBOA in children.

**Methods:** Computed tomography (CT) scans of pediatric patients performed between February 2016 and October 2019 were retrospectively reviewed by two providers. Inter-rater reliability (IRR) for measurements were determined using intraclass correlation coefficient (ICC). Vascular dimensions were correlated with the patient's height, weight and body mass index (BMI) using linear regression analysis. Categorization within Broselow categories were also evaluated.

**Results:** 569 CT scans were reviewed. Measurements of vessel diameter and distance from the common femoral artery (CFA) to aorta zones I and III were determined and grouped by Broselow category (Table 1). Patient age ranged 0-18 years, with a male to female ratio of 1:1. IRR of vessel measurements was excellent with an ICC  $\geq 0.880$ . Vessel diameters had greatest correlation with height and weight, and poorly correlated with BMI.

**Conclusion:** This study represents the largest compilation of REBOA-related pediatric vessel diameter measurements and the first to provide data on distance between access site and balloon deployment zones. Based upon our measurements, the 7 Fr REBOA catheter would be appropriate for the Black, Green, and Orange Broselow categories, and a 4 Fr REBOA catheter would be warranted for all other Broselow categories included in this study.

**Table 1.** Vascular Measurements by Broselow Category

|                                       | Yellow<br>12-14 kg<br>85-98 cm | White<br>15-18 kg<br>98-110 cm | Blue<br>19-23 kg<br>110-121 cm | Orange<br>24-29 kg<br>121-133 cm | Green<br>30-36 kg<br>133-147 cm | Black<br>> 36 kg<br>$\geq 147$ cm |
|---------------------------------------|--------------------------------|--------------------------------|--------------------------------|----------------------------------|---------------------------------|-----------------------------------|
| CFA diameter, mean mm                 | 3.3                            | 3.8                            | 4.1                            | 4.5                              | 4.9                             | 6.0                               |
| Aorta Zone I diameter, mean mm        | 9.2                            | 10.2                           | 10.9                           | 12.0                             | 13.1                            | 15.3                              |
| Aorta Zone III diameter, mean mm      | 6.3                            | 6.9                            | 7.6                            | 8.8                              | 9.7                             | 11.5                              |
| CFA to Zone I, mean cm                | 32.7                           | 36.1                           | 38.7                           | 42.4                             | 46.4                            | 54.1                              |
| CFA to Zone III, mean cm              | 19.0                           | 20.8                           | 22.5                           | 24.3                             | 26.9                            | 31.0                              |
| Recommended REBOA Catheter Size, Fr.* | 4                              | 4                              | 4                              | 4 / 7 <sup>†</sup>               | 4 / 7 <sup>†</sup>              | 7                                 |

\* Based upon ability to maintain <50% OD/AD ratio

<sup>†</sup> OD/AD ratio 60-66% with standard 7 Fr introducer sheath

CFA: common femoral artery, OD: standard introducer sheath outer diameter, AD: access vessel luminal diameter

**FOLLOW YOUR COMPASS®: REBOA MANAGEMENT GUIDED  
BY A NOVEL HANDHELD PRESSURE TRANSDUCER**

Torbjorg Holtestaul, MD; Daniel Lammers, MD; Ian Jones, MD; Jeffrey Conner, MD; Jessica Weiss, MD; Jason Bingham, MD, FACS; Matthew J. Martin, MD, FACS; Matthew Eckert, MD, FACS

Invited Discussant: Doug Schuerer, MD

**Introduction:** Management of truncal hemorrhage utilizing REBOA requires arterial pressure monitoring that can be logistically challenging in austere or emergency settings. Novel pressure transducer devices such as the Centurion COMPASS® device (CD) offer a possible alternative to traditional systems. We sought to assess the feasibility of guiding full and intermittent REBOA in a porcine shock model guided only by CD monitoring.

**Methods:** Ten Yorkshire swine underwent 20% hemorrhage with an uncontrolled vascular injury. Time-based intermittent zone 1 REBOA was performed with volume-based resuscitation to maintain permissive hypotension. Proximal MAPs from a carotid arterial line (AL) were obtained and compared to CD readings from the proximal REBOA port. The REBOA operator was blinded to AL pressures, and guided therapy exclusively with the CD.

**Results:** 60% of animals survived to study endpoint. Mean survival time was 85 (range 32-120) minutes from injury. AL and CD measurements were highly correlated ( $r = .94$ ,  $p < .001$ ). Bland-Altman analysis for comparison of clinical measurements demonstrated a mean difference of 6 mmHg (95% CI -22 to 34 mmHg) for all MAPs, with a mean difference of 3 mmHg (95% CI -6 to 12 mmHg) in a clinically relevant MAP <65 subset.

**Conclusion:** The CD represents a miniaturized and portable arterial pressure monitor that provides a highly accurate and reliable alternative to logistically burdensome AL monitoring to guide REBOA use. The CD was able to guide permissive hypotension and intermittent REBOA without standard AL monitoring equipment.

## **ADVANCED PARTIAL OCCLUSION CONTROLLER FOR REBOA IN A PORCINE MODEL OF HEMORRHAGIC SHOCK**

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Invited Discussant: Matthew Martin, MD

**Introduction:** Targeted regional optimization (TRO), a partial resuscitative endovascular balloon occlusion of the aorta (REBOA) strategy, may mitigate distal ischemia and extend the window of effectiveness for this adjunct. An automated device may allow greater control and precise regulation of flow past the balloon, while being less resource-intensive. The objective of this study was to assess the technical feasibility of the novel advanced partial occlusion controller (APOC) in achieving TRO at multiple distal pressures.

**Methods:** Female swine ( $n=33$ ,  $67.6 \pm 0.876$  kg) were randomized to a target distal mean arterial pressure (MAP) of 25, 35 or 45 mmHg by either manual (MAN) or APOC regulation ( $n=4-7$  per group). Uncontrolled hemorrhage was generated by liver laceration. TRO was performed for 85 minutes, followed by surgical control and a 6-hour critical care phase. Proximal and distal MAP and flow rates were measured continuously.

**Results:** At a target distal MAP of 25mmHg, there was no difference in the mean pressure attained (APOC:  $25.0 \pm 1.00$  vs. MAN:  $27.2 \pm 2.21$  mmHg) but the APOC had significantly less deviance (8.30%) than manual titration (15.8%,  $p < 0.0001$ ). Similarly, at a target distal MAP of 45 mmHg, there was no difference in mean pressure ( $44.5 \pm 1.41$  vs.  $46.2 \pm 1.65$  mmHg) but APOC had less deviance (11.3% vs. 13.8%,  $p = 0.0408$ ). There was no difference between APOC and MAN in mean (35.2 vs. 32.7 mmHg) or deviance (12.6% vs. 13.5%) at a target distal MAP of 35 mmHg, respectively. The APOC made on average 85 balloon volume adjustments per experiment compared to 30 by manual titration.

**Conclusion:** The novel APOC consistently achieved and sustained precisely regulated TRO across all groups and demonstrated reduced deviance at the 25mmHg and 45mmHg groups compared to manual titration.

## PROSPECTIVE VALIDATION OF THE RIB INJURY GUIDELINES (RIG) FOR TRAUMATIC RIB FRACTURES

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Invited Discussant: Andrew Doben, MD

**Introduction:** The Rib Injury Guidelines (RIG) were developed to guide triage of traumatic rib fracture patients to home, regular floor, or ICU and standardize care. The RIG score is based on patient history, physical examination, and imaging findings. The aim of this study is to evaluate triage effectiveness and healthcare resources utilization following RIG implementation.

**Methods:** This is a prospective analysis at a Level I trauma center from October 2017 to January 2020. Adult (age  $\geq 18$  years) blunt trauma patients with a diagnosis of at least one rib fracture on CT imaging were included. Patients before (PRE) and after (POST) implementation of RIG were compared. In the POST group, patients were divided into RIG 1, RIG 2, and RIG 3 based on their RIG score. **(Figure)** Outcomes were readmission for RIG 1 patients, unplanned ICU admission for RIG 2 patients, and overall ICU admission. Secondary outcomes were hospital length of stay (LOS) and mortality.

**Results:** A total of 1107 patients were identified (PRE: 757; POST: 350). Mean age was  $56 \pm 19$  years, 792 (71.5%) were male, and median ISS was 14 [10-22]. The most common mechanism of injury was motor vehicle collision (557; 50.3%), 254 (22.9%) patients had  $\geq 5$  rib fractures, and 53 (4.8%) patients had a flail chest. In the POST group, 74 patients (21.1%) were RIG 1, 123 (35.2%) RIG 2, and 153 (43.7%) RIG 3. No patient in RIG 1 was readmitted following initial discharge, and 2 (1.6%) patients in RIG 2 had an unplanned ICU admission (both for alcohol withdrawal syndrome). POST patients had shorter hospital LOS (3 [1-6] vs. 4 [1-7] days;  $p=0.019$ ) and no difference in mortality (6.9% vs. 8.1%;  $p=0.485$ ). On multivariate analysis, RIG implementation was associated with decreased ICU admission (aOR 0.536 [0.368-0.781];  $p=0.001$ ).

**Conclusion:** RIG is safe and effectively defines triage of rib fracture patients with an overall reduction in ICU admissions, shorter hospital LOS, and no readmissions.

| RIG Score Calculator  |        |
|---|--------|
| Variable  | Points |
| Age $\geq 60$ years   | 4      |
| Incentive Spirometry $< 750$ mL   | 4      |
| Severe pulmonary contusions on CT scan  | 2      |
| Rib fractures $\geq 5$  | 2      |
| COPD, Asthma, or smoker   | 2      |
| Hypoxemia, PaO <sub>2</sub> /FiO <sub>2</sub> $< 100$ mmHg, or chest tube unplugged | 2      |

| RIG Category | RIG Score                                   | Disposition           |
|--------------|---|-----------------------|
| RIG 1        | $\leq 2$                                    | Discharge if possible |
| RIG 2        | 3-9   | Floor                 |
| RIG 3        | $\geq 10$ or severe extra-thoracic injuries | ICU                   |

## **NOT SO FAST- CHEST ULTRASOUND UNDERDIAGNOSES TRAUMATIC PNEUMOTHORAX**

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Invited Discussant: Marc de Moya, MD

**Background:** Ultrasonography for trauma is a widely used tool in the initial evaluation of trauma patients with complete ultrasonography of trauma (CUST) demonstrating equivalence to CT for detecting clinically significant abdominal injury. Initial reports demonstrated high sensitivity of CUST for the bedside diagnosis of pneumothorax. We hypothesized that the sensitivity of CUST would be non-inferior to initial supine chest radiograph (CXR) for detecting pneumothorax.

**Methods:** A retrospective analysis of patients diagnosed with pneumothorax from 2018 through 2020 at a Level 1 trauma center was performed. Patients included had routine supine CXR and CUST performed prior to intervention as well as confirmatory CT imaging. All CUST were performed during the initial evaluation in the trauma bay by a registered sonographer. All imaging was evaluated by an attending radiologist. Subgroup analysis was performed after excluding occult pneumothorax. Immediate tube thoracostomy was defined as tube placement with confirmatory CXR within 8 hours of admission.

**Results:** There were 568 patients screened with a diagnosis of pneumothorax, identifying 362 patients with a confirmed pneumothorax in addition to CXR, CUST and confirmatory CT imaging. The population was 83% male, had a mean age of 45, with 85% presenting due to blunt trauma. Sensitivity of CXR for detecting pneumothorax was 43% while the sensitivity of CUST was 35%. After removal of occult pneumothorax (n=167), CXR was 78% sensitive while CUST was 65% sensitive ( $p<0.01$ ). In this subgroup, CUST had a false negative rate of 35% (n=58). Of those patients with a false negative CUST, 46% (n=27) underwent tube thoracostomy, with 85% (n=24) requiring immediate placement.

**Conclusion:** CUST performed on initial trauma evaluation had lower sensitivity than CXR for identification of pneumothorax including clinically significant pneumothorax requiring tube thoracostomy. Utilizing CUST as the primary imaging modality in the initial evaluation of chest trauma should be considered with caution.

## **UROLOGIC CONSULTATION IMPROVES RENAL SALVAGE RATES AT A REGIONAL LEVEL 1 TRAUMA CENTER**

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Invited Discussant: Daniel Margulies, MD

**Introduction and Objective:** The management of traumatic renal injury has evolved over time, with increasing recognition that a majority of renal injuries can be safely managed conservatively. Although the kidneys are the most commonly injured genitourinary organ, active Urologic consultation for these injuries is highly variable across institutions. We hypothesize that urologic consultation will improve outcomes for patients with renal trauma.

**Methods:** A retrospective analysis of an IRB approved Trauma Registry was queried for all patients sustaining renal trauma, between 2012-2019. We collected baseline demographics, injury characteristics, and details on hospital course on patients sustaining Blunt Injury (BI) or Penetrating Injury (PI). Renal injuries were classified according to the AAST grading system, and expert radiologic review of CT scans was done to classify AAST grade and further characterize radiologic injury patterns. Primary outcome measures were differences in rates of nephrectomy or mortality with urology consult. Logistic regression analysis was performed using R statistical software with significance defined as ( $p < 0.05$ ).

**Results:** A total of 441 patients were admitted for renal trauma. Urology was consulted for a minority of cases, 76 patients (17.0%) over the study period. Among patients being co-managed, Urology performed interventions for the treatment of 17 patients (3.9%) that included 4 pyelograms, 3 ureteral stents, 3 pyelograms with stents, 3 renorrhaphies, 2 nephrectomies, and 2 renal vascular repairs. High grade renal injury (AAST 4&5) was associated with increased odds of urology being consulted (OR 2.5,  $p = 0.0024$ ). Urology consultation was associated with a significantly lower odds of nephrectomy compared to those patients managed by Trauma Surgery (OR 0.19,  $p=0.0060$ ). Urology consultation was associated with lower overall mortality (OR 0.11,  $p=0.027$ ) regardless of injury type. In the setting of high-grade PI trauma, urologic consultation was associated with 15 times higher renal salvage rates, (OR 0.068 for nephrectomy,  $p=0.016$ ).

**Conclusions:** We found an overall low incidence of urology consultation at our trauma center. Despite this, in cases where urology was actively involved there were lower odds of nephrectomy and mortality. In the setting of high-grade PI, urologic consultation resulted significantly higher odds of renal salvage. Urology consultation and multidisciplinary collaboration should be encouraged and may provide an opportunity to improve patient outcomes.

Source of Funding: n/a

## **RISK FACTORS FOR STROKE IN PENETRATING CAROTID TRAUMA IN THE AAST PROOVIT REGISTRY**

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Invited Discussant: Alison Wilson, MD

**Background:** Penetrating carotid injuries are associated with substantial risk of stroke up to 20% in modern studies. However, because penetrating trauma has significantly declined in the past two decades, these injuries are increasingly difficult to study because of small sample size at even the largest centers. This study evaluated all penetrating carotid injuries in the American Association for Surgery of Trauma (AAST) PROspective Observational Vascular Injury Trial (PROOVIT), with the aim of determining factors associated with stroke in these patients.

**Methods:** All patients with a penetrating extracranial carotid injury in the AAST PROOVIT registry from 2012-2020 were evaluated. Isolated external carotid injuries were excluded. Patients with documented post-injury in-hospital stroke were compared to those without in univariate analysis. Significant predictors ( $p < 0.1$ ) for stroke on univariate analysis were included in a multivariate regression.

**Results:** 102 patients from 18 institutions met criteria for analysis. Mean age was  $35 \pm 18$  years and 80% were male. Average GCS on presentation was  $9 \pm 5$ , with an ISS of  $22 \pm 13$ . Operative management of the injury occurred in 51% of patients, who were significantly more hypotensive ( $p = .015$ ) with a lower initial pH ( $p = .001$ ) and more likely to present with hard signs of a vascular injury ( $p < .001$ ). Primary repair was performed in 31% of patients, bypass in 27%, covered stent in 8%, and ligation/coil embolization in 35%. Shunting was rarely performed, 5.9%. The overall stroke rate was 17% (23% in those requiring operative repair vs 10% in those undergoing nonoperative management,  $p = .076$ ). Lack of postoperative antiplatelet therapy (23% vs. 11%,  $p = .03$ ) and need for completion angiography (62% vs 38%,  $p = .02$ ) were associated with a significantly higher rate of stroke on univariate analysis. Time to repair, type of injury, carotid ligation, concomitant jugular vein injury, and jugular vein ligation were not associated with stroke. On multivariate logistic regression, lower GCS and need for completion angiography remained the only independent variables associated with stroke ( $p = .05$  and  $.04$ ).

**Conclusion:** Penetrating carotid trauma undergoing operative management had a stroke rate of 23%. Low GCS on arrival and need for completion angiography are independently associated with post-injury in-hospital stroke. Unfortunately, the ideal treatment strategy (open repair, ligation, use of shunting and endovascular techniques) remains elusive due to small sample size. A dedicated multicenter study may help to achieve higher fidelity data on this rare but devastating injury.

## DELETERIOUS EFFECTS OF PLASMA-DERIVED CELLULAR DEBRIS IN A PORCINE MODEL OF HEMORRHAGIC SHOCK

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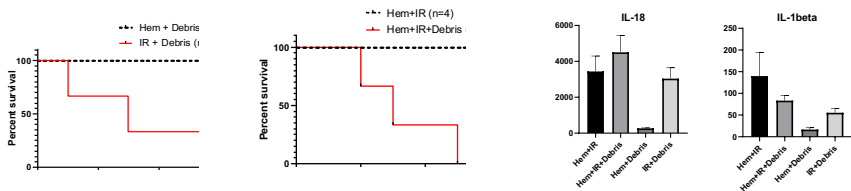
Invited Discussant: Martin Schreiber, MD

**Introduction:** Recent studies identify large quantities of inflammatory cellular debris within Fresh Frozen Plasma (FFP). As FFP is a mainstay of hemorrhagic shock resuscitation, we used a porcine model of hemorrhagic shock to investigate the inflammatory potential of plasma-derived cellular debris during resuscitation.

**Methods:** The porcine model of hemorrhagic shock included: laparotomy with 35% hemorrhage (Hem), followed by 40 minutes of ischemia from supraceliac aortic occlusion (IR) and protocolized resuscitation for 6 hours. Cellular debris (Debris) was added to the resuscitation phase in three groups. The four groups consisted of Hem+IR (n=4), Hem+IR+Debris (n=3), Hem+Debris (n=3), and IR+Debris (n=3). A battery of laboratory, physiologic, cytokine, and outcome data were compared between groups.

**Results:** As expected, the Hem+IR group showed severe time dependent decrements in organ function and physiologic parameters. However, all animals that included the combination of IR and Debris died prior to six hours (see Figure). All animals in the Hem+IR and Hem+Debris survived. Cytokine levels at 30-60 minutes after resuscitation revealed significant differences in IL-18 and IL-1 $\beta$  between all groups (Kruskal-Wallis  $p < 0.05$ ), and IL-18, IL-1 $\beta$ , IL-2, IL-10, and IL-12 between Hem+Debris and IR+Debris.

**Conclusions:** Ischemia and reperfusion appear to prime the immune system to the deleterious effects of plasma-derived cellular debris. In the presence of IR, this model showed 100% lethality when resuscitation included quantities of cellular debris routinely administered to trauma patients during transfusion of FFP. A deeper understanding of the immunobiology of plasma product cellular debris is critical to optimize resuscitation from hemorrhagic shock.



## **IMAGE BASED DETECTION AND ANALYSIS OF STROKE DUE TO BLUNT CEREBROVASCULAR INJURY**

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Invited Discussant: Jamie Coleman, MD

**Introduction:** Patients with blunt cerebrovascular injury (BCVI) are at risk of stroke. The timing of these events is not well understood, yet critical to prevention efforts. In our institution, all patients evaluated for blunt traumatic injuries undergo a screening CTA of the neck, and all patients with suspected strokes undergo MRI of the brain. We conducted a retrospective review to determine the stroke rate and potentially preventable stroke rate, and when these events occur.

**Methods:** Retrospective review of all neck CTAs and head MRIs obtained in blunt trauma patients over a two year period August 2017 to August 2019. All positive studies were individually reviewed to confirm the diagnosis of BCVI and stroke. Stroke was defined as brain MRI-evidence of new ischemic lesions, and each MRI was further reviewed to identify the territory affected. We further extracted the time to aspirin administration and the timing of stroke onset from patients' electronic health records.

**Results:** Records for 6800 patients who sustained blunt trauma were reviewed. Of these, 479 patients (7.0%) were found to have BCVIs, and 24 patients (5.0%) were found to have had a stroke on admission. Of the 455 BCVI patients who did not have a stroke on admission, 12 (2.6%) subsequently had a stroke during their hospitalization. The overall stroke rate of patients with BCVI is 7.5%, and the potentially preventable stroke rate is 2.6% (of all patients with BCVI who do not have a stroke on admission). The median time to stroke in these 12 patients with BCVI was 21:40 hours (IQR 12:54 to 30:58). Only 4 of the 12 patients received aspirin prior to the onset of stroke symptoms. All 36 patients with BCVI and stroke had thromboembolic lesions in the territory supplied by an injured vessel.

**Conclusion:** Stroke in blunt trauma patients occurs in 7.6% of patients admitted with BCVI. Two-thirds of these strokes are evident on admission, and may not be preventable. One-third of BCVI-related strokes occur after admission, but often relatively early, necessitating rapid commencement of preventative treatment. Further studies are required to demonstrate the effectiveness of antithrombotics in preventing stroke in BCVI patients.

## HEMORRHAGE PROGRESSION IN TRAUMATIC BRAIN INJURY OCCURS EARLY AND IS NOT INCREASED BY NAPROXEN

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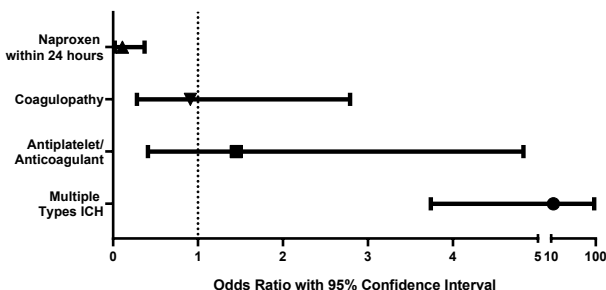
Invited Discussants: Anupamaa Seshadri, MD

**Background:** Non-selective non-steroidal anti-inflammatory drugs, such as naproxen, are often included in multimodal analgesic regimens for trauma patients. However, these drugs are often withheld following traumatic brain injury (TBI) due to concern for progression of hemorrhagic injury (PHI). Additionally, little is known about time from injury to PHI or the effects of naproxen on PHI risk. We hypothesized that, among patients with TBI, administration of naproxen does not increase risk of PHI.

**Methods:** A post-hoc analysis of adult patients with TBI enrolled in the randomized Multi-modal Analgesic Strategies in Trauma (MAST) trial was conducted. The two arms of the trial, MAST 1 and MAST 2, initiated either celecoxib or naproxen within 24 hours, respectively. Serial non-contrast head CTs for each patient were assessed for PHI, using the ABC/2 method of volume calculation. PHI was defined as >33% increase in volume. Coagulopathy was determined according to rTEG. Rates of PHI in MAST 1 vs. MAST 2 were compared via unadjusted analysis. In order to assess the effect of early (<24h) naproxen exposure, multivariable analysis of PHI in only MAST 2 patients was performed.

**Results:** In the trial, 18% (276/1561) of patients had a TBI (MAST 1= 144, MAST 2=132) and 38 (14%) had PHI (MAST 1=17 (12%) vs MAST 2=21 (16%),  $p=0.32$ ). In the MAST 2 group, 3 patients received naproxen prior to PHI. Median time to PHI was 6.1 hours (interquartile range [IQR] 3.8-10.1), while median time to naproxen was 15.5 hours (IQR 9.7-28.1). Patients with PHI were older (62 vs 46 years,  $p<0.001$ ), more severely injured (ISS 29 vs 22,  $p<0.001$ ), and more likely to have multiple types of intracranial hemorrhage (90% vs 42%,  $p<0.001$ ) than those without PHI; they were less likely to receive naproxen prior to progression (14% vs 86%,  $p<0.001$ ). On multivariable analysis, administration of naproxen was not associated with increased PHI (**Figure**). **Conclusions:** The majority of PHI occurred early, prior to naproxen exposure. Although selection bias cannot be excluded, naproxen exposure was not associated with increased PHI.

Relationship between PHI and naproxen on multivariable analysis



## **DEVELOPMENT OF AN AI-DRIVEN POINT-OF-CARE TRAUMA BIOMARKER PANEL TO IDENTIFY INJURY PRESENCE AND SEVERITY**

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Invited Discussant: Andrew Young, MD

**Objectives:** For trauma patients, rapid diagnosis and management of injuries decrease morbidity and mortality. Typically, assessing injuries and their associated severity relies upon CT scanning, which is costly, exposes patients to radiation, and may not be available in resource-poor settings. The objective of this study was to evaluate a point-of-care (POC) biomarker panel for its ability to assess injury presence and severity rapidly.

**Methods:** By developing a systematic approach with AI, ~600 candidate biomarkers were screened in 12 million trauma-related research articles from bibliographic databases. The top 9 biomarkers were identified after conducting a meta-analysis of their diagnostic accuracy. Properdin, Cystatin-C (Cys-C), NGAL, D-Dimer (DD), Complement-5 (C5), Procalcitonin (PCT), Myoglobin (MYO), Protein-C (PC) and, C-reactive protein (CRP) were incorporated into a trauma diagnostic panel for POC use. We conducted a prospective, observational study of 46 trauma patients who presented to our urban, Level-1 trauma center for initial proof of concept clinical validation. A blood sample was drawn immediately upon patient arrival, and injuries were identified via traditional evaluation and imaging. Injury severity was compared to candidate biomarkers and against healthy controls. The area under the curve (AUC) for receiver operator characteristics was used to assess the diagnostic performance of the novel biomarkers compared with traditional methods. Spearman correlation coefficients ( $\rho$ ) correlated between novel biomarkers and injury severity scores (ISS).

**Results:** AUC values of Cys-C and Properdin were 0.99; DD and C5 were 0.88 and 0.84; PC and MYO\* were 0.79 and 0.72 associated with the presence of injury ( $p<0.001$ : \* $p<0.05$ ), respectively. Among these novel biomarkers, ISS was strongly correlated with Cys-C and DD ( $\rho$ ;  $r=0.71$ ,  $r=0.70$   $p<0.001$ ).

**Conclusion:** There is strong potential for a POC biomarker panel to aid clinical decision-making in trauma by identifying both the presence and perhaps severity of visceral injuries. The predictive value of these tests and their correlation with both injuries and injury severity requires further study.

## **SMALL BOWEL OBSTRUCTION IN THE VIRGIN ABDOMEN**

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Invited Discussant: Jose Diaz, MD

**Introduction:** Surgical dogma has historically mandated operative management of small bowel obstruction (SBO) in patients with no previous abdominal surgery. The purpose of this study was to examine the contemporary etiology, management, and outcomes of patients with SBO in a virgin abdomen.

**Methods:** Retrospective analysis of adult patients with confirmed SBO and no previous abdominal surgery who presented to our center between June 2015 and February 2020. Patients were excluded for clinical or radiologic evidence of acute abdomen. Radiology and pathology reports, operative findings, outcomes, and follow up data were analyzed.

**Results:** A total of 66 patients were included, with mean age of 53 years and 71.2% male. 32 patients (48.5%) were managed operatively and 34 (51.5%) non-operatively. The etiology in patients who underwent exploration was adhesions (25.0%), malignancy (15.6%), infectious/inflammatory mass or stricture (12.5%), volvulus (9.4%), bezoar (6.3%), intussusception (3.1%), internal hernia (3.1%), initial Crohn's flare (3.1%), encapsulating peritonitis (3.1%), and ovarian torsion (3.1%). The etiology in patients managed nonoperatively was constipation/fecal impaction (11.8%), malignancy (8.8%), substance intoxication/withdrawal (5.9%), infectious or inflammatory (5.9%), bezoar (2.9%), foreign body (2.9%), and not definitively determined in 21 patients (61.8%). Overall, 8 patients (12.1%) were diagnosed with malignancy, of which 5 underwent operation during the index admission, and 3 following further work-up. The preoperative CT scan was suggestive of malignancy in 7 of the 8 cases. The negative laparotomy rate was 9.4%, in addition to one negative diagnostic laparoscopy (3.1%). 16 patients (50.0%) who underwent exploration required admission to the ICU, compared to 3 (8.8%) who were managed nonoperatively ( $p<0.001$ ). Hospital length of stay was significantly longer in the operative group (10 vs 2 days,  $p<0.001$ ).

**Conclusion:** SBO in patients with a virgin abdomen is most often due to a benign underlying cause. Those resulting from a newly diagnosed malignancy are detected by preoperative imaging in most cases. The rate of negative laparotomy in this population is significant. In the absence of clinical or radiological evidence of acute abdomen, a non-operative approach with close follow up may be appropriate in these patients.

## **BURNOUT REDUCTION IN ACUTE CARE SURGEONS: IMPACT OF A FACULTY SCHEDULE CHANGE AT A LEVEL 1 TRAUMA AND TERTIARY CARE CENTER**

Caitlin Jones, MD; Terence O’Keeffe, MD; Cassandra White, MD; Steve Holsten, MD; Rashid Sayyid, MD; Elizabeth Fox, MD; Andrew Lawson, DO; Medical College of Georgia at Augusta University

Invited Discussant: Jennifer Hartwell, MD

**Background:** Acute care surgeons are prone to burnout due to heavy workload, concurrent clinical responsibilities, and busy in-house call. Modifiable burnout factors have been identified, but few studies have looked for longitudinal effects after change is implemented. We hypothesized that optimizing faculty workflow could decrease burnout without compromising productivity.

**Methods:** We streamlined the faculty schedule at our institution to eliminate 24-hour call by creating weekly blocks of 12-hour day and night call, free from other clinical obligations. Protected academic time was added. The Maslach Burnout Inventory (MBI) and Areas of Worklife Survey (AWS) for health care providers were given to faculty at baseline, 6, and 12 months. Close friends or family members completed the survey based on their perception of the surgeon’s burnout. MBI and AWS proprietary formulas were used to assess change in factors contributing to burnout. Our primary outcome measure was the presence of burnout. Chart delinquency and RVUs were secondary outcome measures assessing for change in clinical productivity.

**Results:** Survey completion rates were 92% for faculty and 75% for family. All burnout risk factors improved at 6 and 12 months compared to baseline. In both the surgeon and family groups, the following percentage improvements were noted in the mean scores of risk factors at one year: workload (74%, 68%), control (38%, 16%), reward (14%, 24%), fairness (69%, 22%), emotional exhaustion (27.5%, 24%), depersonalization (37.5%, 14%), personal accomplishment (12.5%, 2%), community (3%, 5%), values (10%, 15%), and over-all burnout (12.5%, 23.3%). There was a reduction in charts reaching delinquent status. RVU production did not change.

**Conclusion:** This study demonstrates that implementing a weekly, 12-hour call schedule can improve factors which lead to burnout. Improvements were noted in surgeon and family groups alike, signifying not only subjective perceptual improvements, but also an observed change in the surgeons’ behavior. This was accomplished without compromising clinical productivity.

## **CODE CRITICAL AIRWAY: A COLLABORATIVE SOLUTION TO A CATASTROPHIC PROBLEM**

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Emily Rhoades, CRNP; Christine T Trankiem, MD, FACS; Laura S  
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Invited Discussant: Niels Martin, MD

**Introduction:** Airway emergencies (AEs) are infrequent events that can occur suddenly and carry a high risk of morbidity and mortality. In 2006, a multi-disciplinary “Code Critical Airway” Team was created at our institution, with the goal of promoting the least invasive approach to airway management in the emergency situation while maintaining airway stability. This intervention involved hospital-wide airway management education that emphasized a proactive rather than reactive approach. The objective of this study is to examine the demographics of the patients for whom a “Code Critical Airway” is activated, and to examine patient outcomes following this event.

**Methods:** A retrospective chart review was conducted of all patients over 18 years of age on whom a “Code Critical Airway” (CCA) was called from 2008-2020. Patient demographics including age, gender, BMI, admitting diagnosis, location in the hospital, and medical history of conditions pertinent to airway management were collected. The outcomes measured included: number of attempts to secure the airway, intervention performed to establish the airway and airway-associated mortality. The early period of the experience with CCAs (2008-2014) was compared to the later period (2015-2020). Data was analyzed in SPSS 24 using Fishers exact test and Cochran Armitage trend test where appropriate.

**Results:** From 2008-2020 there were 953 CCA events called. Over time, there was a statistically significant increase in the number of CCAs activated. Two hundred seventy-four (29.0%) CCAs occurred in the emergency department, 255 (27.0%) in the intensive care unit, 60 (6.4%) in the step-down unit, 294 (31.1%) on the wards, and 61 (6.5%) elsewhere in the hospital. No single patient-related factor was associated with increased risk of needing a surgical airway in this cohort; interestingly BMI >30 decreased over time. Critical airways were managed with intubation using the Glidescope in 231 patients (25.7%), fiberoptic bronchoscopy in 305 patients (33.8%), aide of a bougie in 48 patients (5.3%), replacement of a prior tracheostomy in 243 patients (26.3%) and creation of a new surgical airway in 85 patients (9.2%). Mortality directly related to an airway event was 6.1%. There was a statistically significant increase in the number of successful first attempts at obtaining an airway comparing our experience in early period from 2008-2014 to the late period from 2015-2020 ( $p<0.001$ ). There was a statistically significant decrease in number of CCAs requiring creation of a surgical airway comparing 2008-2014 and 2015-2020 ( $p=0.022$ ).

**Conclusion:** Inculcation of aggressive early escalation of airway emergencies through implementation of a Code Critical Airway Team has resulted in significant improvement in first attempt definitive airway stabilization and a decrease in the need for surgical airways.

## DOES PRACTICE MATCH TRAINING?

### CONSULTATION PRACTICES IN SURGICAL CRITICAL CARE

Christopher P. Michetti, MD; Susan Evans, MD; Niels Martin, MD; Salman Ahmad, MD; Panna A. Codner, MD; Wendy Greene, MD; INOVA Fairfax

Invited Discussant: Krista Kaups, MD, MSc, MS

**Background:** Despite a defined curriculum, the Surgical Critical Care (SCC) scope of practice may vary depending on local policies, resources, & expertise. Understanding practice patterns may inform educational needs and personnel distribution.

**Methods:** We studied ICU consultation practices by email survey of AAST members. Under 8 medical specialties a list of related diagnoses was provided (*e.g.* Neurology: *stroke, seizures, meningitis, etc.*); respondents were asked for which conditions they would consult that specialist. We also queried confidence in management of clinical categories and opinions about consultation. Descriptive statistics were used.

**Results:** Of 1,682 AAST members, 314 physicians (18.6%) responded (68% male; 79% White; 96.2% SCC certified). Percentage of clinical time spent in SCC was 26-50% in 57%, >50% in 14.5%. Respondents' ICUs were closed (39%), open (25%), or hybrid (36%). Highest average confidence ratings for managing select conditions (1=least, 5=most) were 4.64, ventilator; 4.51, palliative care; 4.44 infections; 4.31 (tie) organ donation, hemodynamics; lowest rating was 3.85, myocardial ischemia. Opinions on consultants' effect on costs were 71% "increase", 20% "no effect", and 9% "decrease". Over half of respondents (53%) agreed or strongly agreed that consultant use increases family confusion about who is in charge of patient care. Out of an average of 20 listed conditions per specialty, respondents tended to consult more frequently for cardiology, hematology, and neurology and less frequently for nephrology, palliative care/geriatrics, GI, infectious disease, & pulmonary. For procedures, few respondents (<10%) consulted for chest tubes (0.7%), central lines (1%), thoracentesis (8.1%), or fasciotomies (9.8%), but most (>90%) consulted for intracranial pressure monitors (95%), percutaneous abdominal drains (91%), cholecystostomy tubes (95.4%), nerve blocks (84.8%), & vena cava filters (82%). For routine intubation 22.1% consulted vs. 61.6% for difficult airway intubation.

**Conclusions:** Use of consultants in the ICU varies based on specialty and diagnosis. Among predominantly surgical intensivists, consultation is primarily requested for conditions where specific interventions are required. These practices have economic and educational implications for SCC.

## **ESTRADIOL REDUCES MORTALITY IN A SWINE MODEL OF POLY TRAUMA AND HEMORRHAGIC SHOCK**

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Invited Discussant: Michael Goodman, MD

**Introduction:** Although  $17\alpha$ -ethynylestradiol-3-sulfate (estradiol) reduces mortality in small and large animal models of controlled hemorrhage, its role in a clinically relevant model of injury is unknown. We assessed the impact of estradiol in a swine model of poly-trauma and hemorrhage.

**Methods:** The study was performed under Good Laboratory Practice regulations, with 30 male uncastrated swine (25-50 kg) subjected to a pulmonary contusion (via a bolt gun), comminuted tibial fracture and 30% controlled hemorrhage over an hour. Animals were randomized to one of five estradiol doses: 0 (control), 0.3, 1, 3 and 5 mg/kg, which was administered at 10-mins post-injury. Subjects received no resuscitation and were observed for 6 hours or until death. Survival data (mins) was collected and analyzed using Cox-proportional hazard regression. Left ventricular pressure-volume loops were collected and used to derive preload recruitable stroke work (PRSW) as a measure of cardiac inotropy. Immediate post-injury values were compared to end-of-study (EOS) values within groups.

**Results:** 6-hr survival for the 0, 0.3, 1, 3 and 5 mg/kg groups was 0%, 50%, 33.3%, 16.7% and 0%, respectively. Following Cox regression, the hazard [95% confidence interval] of death was significantly reduced in the 0.3 (0.22 [0.05-0.93]) and 1 (0.24 [0.06-0.89]) mg/kg groups but not in the 3 and 5 mg/kg groups: 0.49 [0.15-1.64] and 0.46 [0.14-1.47]. Mean time of survival for the entire study period was significantly extended in the 1 mg/kg group (246 min) vs the 0 mg/kg group (96 min) [ $p=0.04$ , t-test]. EOS inotropy was significantly higher than post-injury values in the 0.3 and 1 mg/kg groups ( $p<0.001$ ). Inotropy was unchanged in the 3 mg/kg group, but the EOS values were significantly depressed compared to post-injury data in the control and 5 mg/kg groups ( $p<0.001$ ).

**Conclusion:** Low dose estradiol, even in the absence of fluid resuscitation, reduces mortality and improves cardiac inotropy in a clinically relevant swine model of poly-trauma and hemorrhage. These findings support the need for a clinical trial in human trauma patients.

**THE INTERACTION BETWEEN  $\beta$ -ADRENERGIC BLOCKADE AND THE REVISED CARDIAC RISK INDEX IN RELATION TO MORTALITY AFTER TRAUMATIC HIP FRACTURE SURGERY IN GERIATRIC PATIENTS**

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PH.D.; Tomas Borg, MD, PH.D.; Shahin Mohseni, MD, PH.D.; Orthopedic  
Surgery  
Invited Discussant: TBD

**Introduction:** An association between beta-blocker (BB) therapy and a reduced risk of major cardiac events and mortality in patients undergoing surgery for hip fractures has previously been demonstrated. Furthermore, a relationship between an increased Revised Cardiac Risk Index (RCRI) score and a higher risk of postoperative mortality has also been detected. The purpose of the current study was to investigate the interaction between BB therapy and RCRI in relation to 30-day postoperative mortality in geriatric patients after hip fracture surgery. The hypothesis was that patients with higher RCRI scores will have a greater benefit of BB therapy, in terms of reduced postoperative mortality.

**Methods:** All patients over 65 years of age who underwent primary emergency hip fracture surgery in Sweden between January 1, 2008 and December 31, 2017, except for pathological fractures, were included in the study. Patients were divided into cohorts based on their RCRI score (RCRI 1, 2, 3, and  $\geq 4$ ) and whether they had ongoing BB therapy at the time of admission. A Poisson regression model with robust standard errors of variance was used, while adjusting for confounders, to evaluate the association between BB therapy, RCRI, and 30-day mortality. This analysis was performed on the whole study population as well as within each RCRI cohort.

**Results:** A total of 126,934 cases met the study inclusion criteria. Beta-blocker therapy was associated with a 65% decrease in the risk of 30-day postoperative mortality in the whole study population [adj. IRR (95% CI): 0.35 (0.32-0.38),  $p < 0.001$ ]. The use of BB also resulted in a significant reduction in 30-day postoperative mortality within all RCRI cohorts. However, the most pronounced effect of beta-blocker therapy was seen in patients with an RCRI score greater than 0.

**Conclusions:** Beta-blocker therapy is associated with a reduction in 30-day postoperative mortality, irrespective of RCRI score. Furthermore, patients with an elevated cardiac risk appear to have a greater benefit of beta-blocker therapy.

## HEMORRHAGE INCREASES CAPILLARY CONGESTION IN A PORCINE MULTIPLE TRAUMA MODEL

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Mahuvakar A, McCully B, PH.D. Shibani P, MD. PhD; Schreiber MA, MD,  
FACS, FCCM; Oregon Health & Science University  
Invited Discussant: TBD

**Introduction:** The combination of pulmonary contusion (PC) and hemorrhagic shock are risk factors for the development of Acute Respiratory Distress Syndrome (ARDS) after trauma. Appropriate animal models are critical for testing novel therapies to prevent ARDS.

**Methods:** Anesthetized swine (n=87) were randomized to sham (n=6, immediate euthanasia), control (n=9, instrumentation with 48 hours of ventilation), PC<sub>1</sub> (n=36), or PC and grade V liver injury (PC + LI, n=36). Injured animals randomly receive prothrombin complex concentrate (n=18), swine plasma<sub>2</sub> (n=18), or a swine mesenchymal stem-cell suspension (n=18), or crystalloid, (n=18). After 48 hours the animals were euthanized, and lung biopsies were obtained from all six lung lobes. Tissues were scored by a blinded pathologist for severity of capillary congestion, alveolar edema, acute inflammation, and intra-alveolar hemorrhage. Scores were compared by a generalized linear model with injury, treatment, early death, and interaction terms.

**Results:** Of the 87 animals studied, 12 randomized to PC + LI expired prior to the end of the 48 hours. Treatments did not significantly affect survival. ARDS pathologic scores were: sham 7.5, controls 10.3, PC 10.2, and PC + LI 12.3. Treatment did not affect pathology score. PC + LI scored higher than PC alone after adjusting for treatment effects ( $p = 0.03$ ). PC + LI was also associated with a higher capillary congestion sub-score compared to PC alone ( $p = 0.023$ ).

**Conclusion:** This is the first study to report the added pathologic effects of hemorrhagic shock in addition to PC in a multiple trauma porcine injury model and suggests that hemorrhagic shock magnifies the effects of PC in the development of ARDS by increasing pulmonary capillary congestion. This study will provide mechanistic targets for future interventional trials.

## **DEFINING SEPSIS PHENOTYPES - TWO MURINE MODELS OF SEPSIS AND MACHINE LEARNING**

Allan E. Stolarski, MD, MD; Jiyou Kim, Ph.D.; Jacob Nudel, MD; Sophia Gunn, BA; Daniel Remick, MD; Boston Medical Center

Invited Discussant: TBD

**Introduction:** Sepsis phenotypes have been described in the clinical literature. However, the immunobiology defining the clinically apparent differences in response to sepsis remains unclear. We hypothesize that in murine models of sepsis we can identify phenotypes of sepsis using non-invasive physiologic parameters (NIPP) early after infection to distinguish between different inflammatory states.

**Methods:** Two murine models of sepsis were used: gram-negative pneumonia (PNA) and cecal ligation and puncture (CLP). All mice were treated with broad spectrum antibiotics and fluid resuscitation. High-risk sepsis responders (pDie) were defined as those predicted to die within 72-hours following infection. Low-risk responders (pLive) were expected to survive the initial 72 hours of sepsis. R-Studio was used for statistical analysis and machine learning.

**Results:** NIPP obtained at 6- and 24-hours after infection of 291 mice (85 PNA and 206 CLP) were used to define the sepsis phenotypes. Using lasso regression for variable selection with 10-fold cross validation to prevent overfitting, variables selected to discriminate between phenotypes include 6-hour temperature and 24-hour pulse distention, heart rate, and temperature. Applying the model to fit test data (n=55), area under the curve (AUC) for the receiver operating characteristics (ROC) curve was 0.93. Subgroup analysis of 120 CLP mice revealed a heart rate of less than 620 bpm at 24-hours as a univariate predictor of pDie. (AUC of ROC curve=0.98). Subgroup analysis of PNA exposed subjects (n=121) did not reveal a single predictive variable highlighting the complex physiological alterations in response to sepsis. However, applying the lasso regression and cross validation technique to the PNA subgroup, the following variables were selected: 6-hour percent change in weight from baseline, 6-hour temperature, as well as 24-hour measurements of pulse distention, heart rate, and percent oxygen saturation. (AUC of ROC curve=0.85).

**Conclusion:** In murine models with various etiologies of sepsis, NIPP assessed just 6- and 24- hours after infection can identify different sepsis phenotypes. Stratification by sepsis phenotypes can transform future studies investigating novel therapies for sepsis.

## **THE IMPACT OF COVID STATUS ON COMPLICATIONS IN PATIENTS PRESENTING IN HEMORRHAGIC SHOCK**

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Invited Discussant: Patricia O'Neill

**Background:** Hemorrhagic shock and SARS-CoV-2 infections have each been shown to cause endothelial injury and dysfunctional coagulation. We hypothesized that in patients presenting with hemorrhage, COVID-positive status would result in increased complications, organ failure, and mortality.

**Methods:** All trauma patients admitted 04/20-07/20 were evaluated.

Patients were included in analysis if they (1) were 16 years or older, (2) presented in hemorrhagic shock and (3) received emergency release blood products in the trauma bay. Patients who died in the emergency department or prior to collecting nasal swab for COVID were excluded. Patients were divided into COVID(+) and COVID(-). Data analyzed by STATA 12.1.

**Results:** 255 patients met inclusion criteria; 22 (9%) were COVID(+), 233 were COVID(-). There were no differences in demographics, injury severity, initial lab values, or transfusions between groups. COVID(+) had significantly higher complications (TABLE). 30-day survival was lower (62 vs 78%) in the COVID(+) group, but did not reach statistical significance ( $p=0.08$ ). Controlling for age, sex, and ISS, COVID(+) patients had a 70% decreased odds of survival (OR 0.28, 95% C.I. 0.09-0.81;  $p=0.019$ ).

**Conclusion:** COVID(+) status was associated with a 2-fold increased risk of major complications and 70% decreased odds of survival in hemorrhagic shock patients. Given the endothelial injury sustained during hemorrhage, it is not surprising that COVID-related damage to the endothelium is additive and results in worse outcomes in an already critically ill population.

## THE NEW FACE OF WAR: CRANIOFACIAL INJURIES FROM OPERATION INHERENT RESOLVE

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Invited Discussant: Joseph Galante, MD

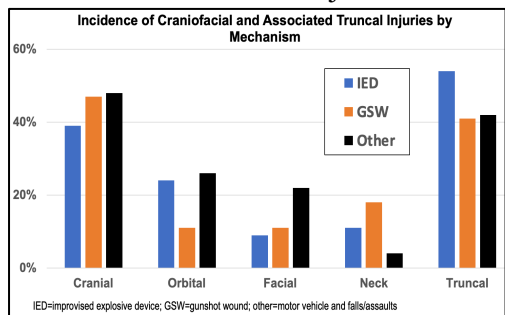
**Introduction:** During the last 20 years of conflict in the Middle East, improvements in body armor and the use of improvised explosive devices has resulted in an increased incidence of complex craniofacial trauma (CFT). Currently, CFT comprises up to 40% of all casualties. We present new data from the recent conflict in Iraq and Syria during Operation Inherent Resolve.

**Methods:** Data was collected for patients treated at Role 1, Role 2, and Role 3 facilities in Iraq and Syria over a one-year period. During this time, a specialized Head & Neck surgical augmentation team was deployed and co-located with the central Role 3 facility. Data included: injury type and mechanism, triage category, initial managing facility and subsequent levels of care, and procedures performed.

**Results:** Ninety-six patients sustained CFT over the study period. The most common injuries were soft tissue (57%), followed by cranial (44%) and orbital/facial (31%). Associated truncal and/or extremity injuries were seen in forty-six patients (48%). There were marked differences in incidence and pattern of injuries between mechanisms (Figure, all  $p < 0.05$ ). While IEDs had the highest rate of cranial and truncal injuries, GSW and blunt mechanisms had higher incidences of orbital/facial and neck injuries.

Overall, 45% required operative interventions including complex facial reconstruction, craniotomy, and open globe repair. Mortality was 6% with 83% due to associated severe brain injury. Most patients were local nationals (70%) who required discharge or transfer to the local healthcare system.

**Conclusion:** Complex craniofacial trauma is increasingly seen by deployed surgeons, regardless of subspecialty training or location. Deployment of a centrally located Head & Neck team greatly enhances the capabilities for forward deployed management of CFT, with excellent outcomes for both U.S. and local national patients.



**LIFE THREAT DURING ASSAULTIVE TRAUMA: CRITICAL PERI-TRAUMATIC RISK FACTORS FOR INJURED PATIENTS**

Sydney Timmer-Murillo, MS; Andrew T. Schramm, PhD; Terri A. deRoos-Cassini, Ph.D.; Medical College of Wisconsin

Invited Discussant: Tracey Dechert, MD

**Introduction:** Rates of PTSD among injury survivors are higher relative to the general population. Screening while hospitalized has improved identification of those most at-risk for PTSD following injury. Yet, more is needed to identify which specific factors lead to the quickest and most parsimonious risk identification. The current study evaluated whether trauma type (assaultive vs. non-assaultive) and perceived life threat during the trauma combined led to greater PTSD symptom cluster endorsement 1 month and 6 months post-injury.

**Methods:** Data were combined from two prospective longitudinal studies of adult injured trauma survivors admitted to two level 1 trauma centers. While hospitalized, participants completed a screening measure assessing perceived life threat during trauma. Mechanism of injury (MOI) was collected via record review and was collapsed into two categories: assaultive and non-assaultive. The Clinician Administered PTSD Scale (DSM-5) was administered at 1 month and 6 months after injury.

**Results:** Four 2 (time) X 2 (life threat) X 2 (trauma type) analyses of variance (ANOVA) examined whether life threat and assaultive trauma led to greater symptoms across the four PTSD symptom clusters (intrusions, avoidance, hyperarousal, and negative mood) at 1 and 6 months post-injury. Results showed significant interaction effects of life threat, trauma type and time for intrusive symptoms,  $F(1, 82) = 7.63, p = .008, \eta^2 = .08$ , and avoidance symptoms,  $F(1, 82) = 7.75, p = .007, \eta^2 = .09$ . Individuals with life threat during assaultive traumas maintained heightened intrusive symptoms across time and increased avoidance at 6 months. On the other hand, participants with either life threat or assaultive traumas had decreased symptoms at 6 months. Additional findings across symptom clusters also found.

**Discussion:** Individuals with assaultive traumas who experienced life threat may represent a specific at-risk group following injury. This study highlights a need to assess for these peri-trauma factors and supports early intervention targeting avoidance and intrusive symptoms in this group.

## **ACUTE STRESS DISORDER IN TRAUMA PATIENTS DISCHARGED IN 72 HOURS OR LESS**

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Invited Discussant: Cherisse Berry, MD

**Introduction:** Acute Stress Disorder (ASD) is a psychiatric condition affecting individuals exposed to real or perceived trauma. ASD affects up to 33% of patients admitted following injury and is associated with subsequent post-traumatic stress disorder (PTSD), but diagnosis requires the presence of symptoms at 72 hours following the traumatic event. Many patients evaluated for traumatic mechanisms are discharged prior to 72 hours, but the risk of ASD remains. The aim of this study was to quantify the prevalence of acute stress disorder in trauma patients admitted for fewer than 72 hours.

**Methods:** We performed a prospective, observational study of trauma patients discharged prior to 72 hours following injury at our ACS Level I Trauma Center between June 2020 and December 2020. Participants were administered an institutional screening tool via telephone following hospital discharge. Those screening positive were then administered the diagnostic Acute Stress Disorder Scale (ASDS) tool. The rate of acute stress disorder was calculated and bivariate comparisons between participants who met diagnostic criteria and those who did not were performed to identify risk factors for the development of acute stress disorder.

**Results:** During the study period, 693 patients were evaluated for trauma, with 335 discharged prior to 72 hours. 133 patients were enrolled in the study, with 116 patients ultimately participating. Overall, subjects had a median age of 54, were largely male (66%), and had a median injury severity score (ISS) of 9. Forty patients (34%) screened positive via the institutional screening tool, with 14 (12%) ultimately demonstrating ASD by ASDS. Participants who developed ASD were more likely to be female (71 vs. 30%,  $p=0.05$ ), African American (43 vs. 12% White,  $p=0.016$ ), spend less time in the hospital overall (1-2 vs. 2-3 days,  $p=0.045$ ), and have a lower ISS (6 vs. 9,  $p=0.041$ ).

**Conclusions:** A significant number of trauma patients discharged prior to 72 hours develop ASD. While the physical injuries may not require extended hospitalization, these data emphasize the need for reassessment of injured patients following discharge and the importance of developing pathways for trauma patients to access mental health resources.

## **EARLY PREDICTORS OF POST DISCHARGE DEATH IN THE ELDERLY TRAUMA POPULATION TO GUIDE PALLIATIVE CARE DISCUSSIONS**

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**Introduction:** Geriatric trauma patients are at higher risk for both inpatient and post-discharge mortality(PDM). Patients at high risk would benefit from early goals of care discussion, however this population remains poorly characterized. This study aims to identify admission variables that predict PDM within 30 days to help determine prognosis early in a patient's hospital stay. We hypothesize that pre-injury functional status and injuries of the head will predict post-discharge mortality in geriatric trauma patients.

**Methods:** Patients  $\geq 65$  y admitted between 7/2008 and 12/2017 were identified in a level I trauma registry. Patient identifiers were used to extract and merge National Death Index data with registry data. Four mortality outcomes were investigated: inpatient death, death  $\leq 30$  days post discharge, 31-180 days, and 181-365 days. Cox regression was used in each outcome group combined with patients who survived  $>365$  days to determine hazard ratios of our predictor variables, including, but not limited to: Age, gender, hospital length of stay, Glasgow Coma Score(GCS), baseline functional independence measure(FIM), and abbreviated injury scale(AIS).

**Results:** Of 3617 patients were identified, 881 (24%) died within 1 year. Among those deaths, 233 (26%) died during their hospital admission, 194 (22%) died within 30 days post discharge, 285 (32%) died 31-180 days, and 169 (19%) died between 181-365 days. Older age, male gender, lower GCS, and lower FIM had significant hazard ratios in all outcomes. Specific to 30-day PDM, patients were 22% more likely to die for each point increased in AIS head/neck (HR 1.22, 95% CI 1.03-1.44) and 19% more likely to die for each point increase in AIS extremities (HR 1.19, 95% CI 1.02-1.38).

**Conclusion:** Most deaths among geriatric trauma patients occur post discharge. Over half of those deaths occur within 6 months, making them Hospice-eligible at the time of discharge from the hospital. Patients with baseline functional disability who suffer severe injuries to the head or extremities are at highest risk and should be targets for early goals of care conversations and recommendations that involve palliation.