2017 Research Abstracts Selection for Podium or Poster Presentation

TOP PODIUM PRESENTATION

Social Media and Military Medicine

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Background: As technology in communications advances, best practices in tactical or military medicine can be shared at the speed of creation. Currently best practices are spread through the publishing of texts, scholarly journal articles, word of mouth, or during periodic refresher courses. This leaves many tactical medical providers and medical directors using different protocols and recommendations for patient care. The goal of my presentation is to inform and empower medical providers to more efficiently disseminate needed medical information to medics in their charge utilizing modern communications techniques.

Methods: Trial and error and 3 years of experience.

Results: 160,000 hits on our website made by over 70,000 unique IP addresses around the world on our blog posts, podcasts and recommendations.

Discussion: Due to a variety of reasons, military medics are not getting the most up to date information regarding the treatment of casualties throughout the gamut of tactical medicine. I will submit a layered approach using multiple solutions in improving communication of current best practices and recommendations from unit surgeons down to the end-user medic on the ground. This will include discussions on social media use, and etiquette, by military members to include different social media platforms as well as current USSOCOM and DOD policy. Depending on the content to be released, various social media sites are better used for certain purposes. I will explain the nuances I have found in my experiences with some of these different sites and platforms. I will also directly challenge medical directors to make better use of the tools with which they should already be comfortable using including email lists and portal pages and explain some of the issues of PERSEC and OPSEC pertaining to the use of social media. Platforms which will be discussed will include: email, online surveys or quizzes, websites, blogs, podcasts, vodcasts, Live Stream services, Facebook, Twitter, Reddit, Pinterest, Intagram, LinkedIn, Google+ and Hangouts, Slack, Skype and Snapchat.

TOP POSTER PRESENTATION

Physiologic Stress and Performance Evaluation: Simulating Damage Control Surgery in An Austere Environment

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Background: Current methods of evaluating human performance are subjective and potentially unreliable. This study attempted to evaluate the physiologic stress of surgeons performing a simulated damage control procedure in a weightless environment.

Methods: Ten surgeons, of various experience, performed simulated damage control procedures in 0g and 1g environments. Simulated weightlessness was created in parabolic flight of a Falcon 20 aircraft. A hierarchical decomposition (HD) model of the procedure was developed to facilitate definable tasks during the 20-25 second periods of weightlessness for each parabola. Task time and volume of hemorrhage was recorded for each procedure. Surgeons wore an Equivital EQO2 Sensor Belt, capable of measuring heart rate and ECG signals. Time domain analysis of Heart Rate Variability (HRV) was conducted based on the beat-to-beat/NN intervals. Mean and standard deviation of the interbeat interval (IBI) was evaluated. Percentage of successive normal cardiac IBI greater than 50 msec (pNN50) was also calculated. Ten subjects were evaluated over three days. Five surgeons had less than 5 years of experience, three 5-15 years of experience and two more than 15 years. Two surgeons had previous parabolic flight experience.

Results: Each surgeon successfully completed each task. Average time and blood loss for the 1g and 0g tasks were 192.4 sec/408.8mL and 180.2sec/307.6mL. During the 1g and 0g tasks the IBI was 756.7 msec and 704.1 msec. The mean pNN50 for the duration of monitoring was 23.4% across all surgeons, 21.9% during the 1g simulation, and 20.3% during the 0g simulation. The two senior surgeons had an increased pNN50 by 16.9%.

Discussion: HRV analysis showed an increased amount of physiologic stress with simulated tasks in 0g with greater stress occurring in the older surgeons. Further extrapolation to new/novel environments to train medics and role one providers needs to be explored to help tailor training into future fights.

PODIUM PRESENTATIONS

Two New Effective Tourniquets for Potential Use in the Military Environment: A Serving Soldier Study

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Background: Tourniquets have been used extensively during modern Middle Eastern conflicts. Despite its successes, the C-A-T™ has some shortfalls; principally its inability to reliably control lower limb bleeding when applied to the mid-thigh. We tested two tourniquets that may represent an improvement to the C-A-T™; the Tactical Mechanical Tourniquet, and the Tactical Pneumatic Tourniquet.

Methods: The Tactical Mechanical Tourniquet and Tactical Pneumatic Tourniquets were applied to both lower limbs of twelve healthy service personnel. The sequence of application was randomly generated. Tourniquets were tightened at mid-thigh level until popliteal artery occlusion was achieved. Popliteal artery occlusion was measured by a consultant radiologist using a portable ultrasound machine. Time to complete occlusion, number of windlass revolutions, and pain scores were collected. Non-normally distributed data are present as median (IQR). Ordinal non-parametric data are analysed by Mann-Whitney U testing.

Results: Participants had a median age of 32.5 (28-35). Both tourniquets demonstrated complete occlusion of the popliteal artery in all limbs (n=24). No participants dropped out due to intolerable pain, or any cause. The mechanical tourniquet achieved arterial occlusion after a median of 3.8 (3-4) turns, and 16 (12-20) seconds. The pneumatic tourniquet achieved arterial occlusion after a median of 30.5 (25-32) pumps, and 11 (7-12) seconds. Median pain scores for the mechanical tourniquets were 4.5 (3-7) (maximum pain) and 4.0 (2-7) (pain when locked). Median pain scores for the pneumatic tourniquet were 5 (2-6) (maximum pain), and 5 (2-6) (pain when fully applied). There was no statistical difference in maximum pain scores between the Tactical Mechanical Tourniquet and the Tactical Pneumatic Tourniquet (p=0.75).

Conclusion: Both tourniquets completely occluded the popliteal artery in all participants within an acceptable pain threshold. Further testing is required before the presented tourniquets can be taken to the battlefield.

Enhanced Medical Simulation Training Center Concept: Training for the 21st Century Battlefield
COL Dan Irizarry; JPMO MMS/ PEOSTRI; LTC Steve Delellis, USASOC Chief of Training; SFC Chris Perry, USASOC; SFC Dave Lowe, USASOC; SCPO Ruben Dacosta, MARSOC Senior Enlisted Medical Advisor; Rich Ciuk, MSTC NCOIC; CAPT Scott Cota, USSOCOM Surgeon; LTC Rob Carter, PEOSTRI, Product Manager, MSTC; SGM Litt Moore

The Army's Medical Simulation Training Center (MSTC) is a capability originally designed and fielded to support the Army's requirement for Combat Medic 68W validation and sustainment and to train a limited number of combat lifesavers for units without medics. Since system fielding, user feedback and utilization demonstrates the current MSTC system configuration is not properly scoped for user's demands. Specifically, it does not support the throughput desired by Commanders to train first responders. It does not adequately support collective unit tactical medical training tasks. It is not scalable to the needs of units and installations or responsive to operational requirements to surge to support missions. It does not support emerging requirements for medical readiness in prolonged evacuation environments. It does not support the full spectrum of medical training required and desired by stakeholders such as surgical and telemedicine training.

The Army Medical Department Center and School/Health Readiness Center of Excellence (AMEDD C&S/HRCOE) in coordination with the Army Program Executive Office for Simulation, Training and Instrumentation (PEOSTRI) and user stakeholders is leading an effort to address these shortcomings through revision of the current MSTC capability production document, MSTC CPD Increment 2. MSTC Increment 2 will establish a program of record designed to meet the medical simulation and training needs from point of injury first responder training to forward surgical training capability and expand the role of the MSTC as a test and evaluation platform for emerging technologies. MSTC Increment 2 will posture the Army to build and sustain the Commander's casualty response system to meet the needs of an unpredictable operating environment.

Performance Evaluation of an Oxygen-Concentrator Upgraded With an Oxygen-Recycling System in Order to Obtain Safe and Sufficient Oxygen Delivery in Austere Combat Environments
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Background: In our search to supply our SOF team-medics with a safe, lightweight, small logistics but performant system to deliver sufficient oxygen to their patients far forward we connected an oxygen-recycling system to an oxygen-concentrator in order to augment performance of the concentrator. The oxygen-recycling system is a rebreather with a closed circuit which recaptures the exhaled O2 . This system can provide up to 100% FiO2 with flow rates of only 0.8 -2l/min O2. By rebreathing, the exhaled oxygen is reused and a soda-lime cartridge absorbs the exhaled CO2. These O2-flow rates are mostly provided by conventional oxygen-cylinder. We tested if the recycling system gave same performance if O2 was provided by a lightweight oxygen-concentrator.

Methods: The study was conducted with Wenoll-system® as the oxygen-recycling system and was connected to a two-compartment adult lung model (Dual Test Lung®) controlled by a Maquet Servo I ® ventilator. Different minute volumes were investigated (MV: 5 to 20l/min). We used either classic O2-cylinder (B2 Air Liquide®) or lightweight O2-concentrator (Sequal Saros®) to ensure a continuous flow rate of 2L/min O2. The FiO2 and MV measurements were made using a iWorx® acquisition system (GA207 gas analyzer and analog / digital IX / 228s) and LabScribe II® software. Statistical test used: ANOVA followed by a post hoc test (Tukey).

Results: After a period of 5 minutes necessary for the denitrogenation of the Wenoll system® dead volume, the FiO2 reached a value of 100% with the O2 cylinder and 92% with the O2-concentrator.
Discussion: For minute –ventilations from 5 to 20L/min, by using a lightweight oxygen-concentrator upgraded by the Wenoll® oxygen-recycling system, we can administer for a long period FiO2 near 92% with an O2 flow rate of only 2L/min. Period is only limited by battery-life of oxygen-concentrator and soda-lime cartridge-life (about 5 hours).

A Randomized Comparative Assessment of Three Surgical Cricothyrotomy Techniques on Airway Mannequins

LCDR Jillian Dorsam, DO, Julie McLean, PhD, Gregory Zarow, PhD, Alexandra Walchak, MPH and LCDR Sean Conley, DO, Combat Trauma Research Group, Naval Medical Center, Portsmouth, VA

Background: Airway obstruction is the third leading cause of preventable battlefield death, so effective surgical cricothyrotomy (SC) is essential for Special Operations Medicine. However, SC failure rates remain unacceptably high. Ideally, SC should be a rapid, simple, easily learned, and reliably performed in austere environments. Presently, TCCC has approved the Tactical CricKit® (TCK), Control-Cric™(CC), and the Bougie-assisted Technique (BAT) for SC. However, no previous studies have contrasted TCK, CC and BAT in application time, application success, participant ratings, and participant preference.
Methods: Navy Corpsmen (N=25) were provided 15min instruction followed by hands-on practice with each technique on airway mannequins, then were randomly assigned to sequence for applying each device using a within-subjects design. Application time, application success, participant ratings, and participant preference data were analyzed using repeated-measures ANOVA and non-parametric statistics at $p<.05$.
Results: CC (M=184sec) was significantly slower than TCK (M=117sec) or BAT (M=135sec) in overall application time. Success was significantly greater for BAT (76%) than for CC (48%) or TC (40%). CC was rated significantly lower than TCK and BAT in ease of application, effectiveness, and reliability. Preference was significantly higher for TCK (58%) and BAT (42%) than for CC (0%).
Discussion: The Control-Cric™ displayed the slowest application times, poorest success rates, lowest ease/effectiveness/reliability ratings, and 0% preference. The Tactical CricKit® had the fastest application times, highest ease/effectiveness/reliability ratings, and greatest preference, but the poorest success rates. The Bougie-assisted Technique was intermediate in application times,

ease/effectiveness/reliability ratings, and user preference, but had the highest success rates. This study was limited by the use of mannequins and post-testing surveys indicated that the Control-Cric™ blade design needs improvement. Combined, these findings indicate that none of these products are ideal for surgical cricothyrotomy in Special Operations Medicine, but that without improvement to the blade design, the Control-Cric™ cannot be recommended.

Comparison of Blind Insertion Airway Devices (BIAD) in a Truly Blind Environment

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Background: Direct Laryngoscopy (DL) utilizes a laryngoscope with a light source to visualize anatomical structures. In a tactical situation, using a light source in a poorly lit environment may give away ones position with potentially deadly consequences. Blind insertion airway devices (BIAD) do not require a light source for use. Four such devices are: the King LT, Air-Q, LMA, and I-Gel. The study goal is to compare accuracy, ease of use, and speed of insertion for each of these devices in a dark environment. In this pilot study, participants include local pre-hospital providers and emergency medicine residents. Study performed on a standardized mannequin in a controlled, dark environment.

Methods:
1. Signed informed consent of study participants obtained (planned 60 participants)
2. Shown videos demonstrating insertion of each of the 4 devices.
3. Participants given the option of up to two practice attempts with each device.
4. Participants given random device in a sealed plastic bag, BVM placed was adjacent to mannequin within reach of study participant, performed on ground for safety.
5. Lights turned off and participants initiated timing when opening bag or voiced starting.
6. Upon insertion and connection of BMV, participants voiced completion and timer stopped.
7. Investigators confirmed adequate placement and ventilation.
8. Participants scored ease of use of each device by completing a questionnaire containing a 4-point Likert scale of: very easy (1), easy (2), hard (3), very hard (4)

The resultant data will be analyzed using ANOVA to compare the time to intubation using all devices. Successful intubation will be analyzed using Cochran's Q Test. The qualitative data derived from the 4-point Likert scale will be analyzed using Kruskall-Wallis test to compare the ease of use for all devices. All data de-identified and Likert scale not correlated with time taken to successfully intubate.
Full results and discussion pending.

Airway Management on the Battlefield – What is the Current State of the Art?

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Airway management is the second leading cause of potentially preventable death on the battlefield. Recent data from Iraq and Afghanistan demonstrates 5-10% of combat casualties required emergent

pre-hospital airway intervention and at least 2% had airway compromise as the likely cause of death. Improvements in personal protective equipment have led to increased frequency of wounds to the head, neck, and airway structures; this injury pattern has not been seen in previous conflicts. Such distortion of anatomical landmarks to the face and neck further complicates the airway management procedure. In part because of these factors, the Tactical Combat Casualty Care (TCCC) guidelines on airway interventions recommend positioning maneuvers followed by minimally invasive airway procedures (e.g. nasopharyngeal airway). If unsuccessful, immediately move to surgical cricothyrotomy. However, the technical challenges associated with surgical airway placement, in conjunction with relatively little training exposure for most military medics, have led to an estimated 25-33% cricothyrotomy failure rate. Traditional orotracheal intubation is not considered a viable option in pre-hospital combat care because of the high level of skill needed. Prior data from the REACH study and elsewhere suggest unsatisfactory utilization and success rates. An important observation to make regarding the current state-of-the-art in pre-hospital airway management is the lack of significant technological advancement in the techniques and tools. This is in marked contrast to hemorrhage control (e.g. tourniquet technology, hemostatic agents, junctional tourniquets). In this review, we will describe the history of combat airway management and the modalities currently in use as well as the lack of a scientifically vetted research model for study of new product solutions. We will propose a research and development agenda for advancements in combat airway management to improve survival on the battlefield.

Bigger is Better: Comparison of Alternative Devices for Decompression of Tension Hemopneumothorax in the Setting of Hemorrhagic Shock

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Background: Standard 14-gauge angiocatheter (14G AC) has an unacceptably high incidence of failure in treatment of tension pneumothorax (tPTX). Little is known regarding the interplay between hemorrhage and tPTX or the effectiveness of decompression during hemorrhagic shock. We hypothesized that increased hemorrhage predisposes tension physiology and that needle decompression would fail more often as hemorrhage worsens.

Methods: This is a post-hoc analysis of data from our recent comparison of 14G AC to 10G AC, modified Veress needle (mVN) and 3mm laparoscopic trocar (LT) conducted in a Yorkshire swine positive pressure ventilation tension hemopneumothorax (t-H/PTX model). 10% estimated blood volume (EBV) was instilled sequentially into each hemithorax and tension physiology induced with CO2 insufflation via transdiaphragmatic balloon trocars. Susceptibility to tension physiology was extrapolated from the amount of CO2 instilled and time to intervention. Incidence of failure was compared between the 10% and 20% EBV hemorrhage groups (Class 1 and 2 shock, respectively).

Results: 196 t-H/PTX decompression events were evenly distributed between device and degree of hemorrhage. No differences were noted in the amount of CO2 instilled or time to initial intervention. Overall, Class 1 shock had a lower incidence of failure compared to Class 2 shock (7% vs 23%, p=0.002). For larger caliber devices (10G AC and LT), there were no difference between shock groups, while

smaller caliber devices (14G AC and mVN) had more failures and longer time to rescue as shock increased.

Conclusion: Worsening hemorrhagic shock did not predispose tension physiology in this model. However, smaller caliber devices were associated with more failures and longer time to rescue in Class 2 shock suggesting that tension physiology may contribute to a more refractory shock state. Use of larger devices for rapid decompression may have benefit and further study with more profound hemorrhage and spontaneous breathing models is warranted.

Environmentally Stable Point of Care Blood Analysis Device

K.T. Reaves, Ph.D. (PI), Jared Mike, PhD, Chris Obrien, PhD, Sanjiv Lalwani, PhD, Gavin Garvey, PhD, Brian Watkins, Jessica Potts, Billy McCulloch, Thomas Peterson and Tyler Houseweart, Lynntech, Inc., College Station, TX; Russ S. Kotwal, MD, MPH, Prehospital Specialist and Consultant, College Station, TX; Harold R. Montgomery, NREMT, Prehospital Specialist and Consultant, Lithia, FL

Background: As identified by the U.S. Special Operations Command, a capability gap exists for providing rapid, comprehensive, lab-quality blood analysis in austere prehospital environments. Traditional blood tests rely heavily on centrifugation and enzymatic testing. Centrifuges are heavy and not well suited for prehospital personnel. Enzymatic tests are inherently environmentally unstable; suffering greatly from temperature changes and often requiring specific buffer environments for proper function. Ideal would be a simple, compact, lightweight, hand-held, and environmentally stable device with long storage life and no performance degradation. Both acute and prolonged field care scenarios would benefit from such a device.

Methods: As Phase I Small Business Innovation Research, Lynntech proposed to create a novel series of electronic and electro-optical tests that can be integrated into a single disposable microfluidic cartridge. From a small sample of blood, these tests would provide rapid, accurate, and environmentally-stable measurement of multiple biomarkers of interest (sodium, potassium, calcium, chloride, pH, hemoglobin, hematocrit, ABO/Rh, lactate, glucose, creatinine, urea nitrogen, pCO2, pO2, TCO2).

Results: Through novel approaches, Lynntech demonstrated accurate performance and consistent environmental stability from non-enzymatic tests and microfluidic separation techniques that avoid centrifugation requirements. All tests, except for the zero user input requiring ABO/Rh paper-based assay, did not rely on enzymes. Performance was verified through whole human blood or plasma. Initial target biomarkers (sodium, potassium, calcium, chloride, pH, hemoglobin, hematocrit, ABO/Rh, lactate) were measured in physiologically relevant ranges with high reproducibility, demonstrating overall utility for point-of-care blood analysis.

Conclusion: Simple, compact, lightweight, hand-held, near-real-time, lab-quality, point-of-care blood testing with realistic nominal storage requirements for austere environments is possible. This blood analysis will aid in management of patients with traumatic battle and non-battle injuries, as well as medical and surgical illnesses. Additional effort is required to miniaturize, ruggedize, and integrate components and complete this comprehensive blood analysis device.

Help is Just a Call Away: Variability in Critical Care Teleconsultation Cases

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Background: Special Operations Forces (SOF) Medics operate in environments with limited medical support and long distances to definitive care. In these environments, prolonged field care (PFC) of critically ill patients is a reality for SOF Medics despite having limited training or experience in delivering this level of care. The Virtual Critical Care Consultant (VC3) service, staffed by critical care specialists, was started to provide medics with on-demand consultation during PFC. To better characterize the nature of user needs, we reviewed consultations to VC3.

Methods: We reviewed and coded all available emails sent to the VC3 email distribution list. We analyzed real-world (real) and training (FTX) cases separately.
Results: There were 37 cases available to review (4 real, all with data, and 33FTX, 27 [73%] with data). FTX cases reviewed were about half of all consultations because many utilized telephone only communication. Real case mix was: 50% trauma, 50% infectious disease. FTX case mix was 48% burns, 15% infectious disease, and 11% gastrointestinal bleeding. Medics asked 29 clinical questions, (2/real and 1.3/FTX) the most common being about burn management including escharotomy (28%), general management (24%) and compartment syndrome management (7%). From 13 cases (4 real, 9 FTX), consultants made 34 recommendations, the most common being about antibiotics (18%), escharotomy (12%), fluid management (12%, including blood transfusion), and pain control (9%). There was documentation of 19 procedures: escharotomy (32%), extremity splinting (16%), blood transfusion (10%), and wound debridement and tube thoracostomy (each 5%). On average, VC3 was contacted 123 hrs and 14 hrs hours after care began in real and FTX cases, respectively.

Discussions: This review of VC3 demonstrates the complexity of care faced by SOF medics and the potential benefits of telemedicine consultation. It is limited by data availability. Differences between real and FTX case mix are thought provoking.

Technology Utilized to Support Virtual Critical Care Consultation (VC3) for SOF: A Review of the First Nine Months

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Background: As operations shift from mature theaters to Grey Zone environments, SOF medics rarely have rapid MEDEVAC capabilities to definitive care. Consequently, Prolonged Field Care (PFC) has been supported by the development of the Virtual Critical Care Consult (VC3) service to provide SOF medics access to critical care expertise 24/7.

Methods: We reviewed all available emails sent to or from the VC3 email distribution list during its first nine months of service. We analyzed real-world (real) and training (FTX) cases separately to assess what technology was utilized during the consultation.

Results: We identified thirty-seven cases (4 real, 33 FTX) for review. FTX cases reviewed were about half of all training events supported by VC3, however many exercises did not utilize email, therefore were not available for review. Technology used in real cases included: telephone 100%, text messaging 25%, video-teleconsultation (VTC) 0%, email 100%, (50% included images), asynchronous vital signs 25% (image sent by email) and synchronous vital signs 0%. Technology used in FTX cases included: telephone 100%, text messaging 0%, VTC 3%, email 94% (90% included images), asynchronous vital signs 90%. Synchronous vital signs were attempted unsuccessfully in one case. Video was never sent by email; one FTX case, however, sent video by text. 75% of real cases sent 3-5 emails, whereas only 12 % of FTX cases sent 3 or more emails.

Discussion: All consultations were successful using near-universally available, low-bandwidth, telecommunications technologies. Differences in volume of emails between real and FTX cases likely reflects differences in patient care timelines and duration of treatment. Asynchronous communication via email or text and synchronous communication via telephone are immediately available solutions to increase critical care experience during PFC and may reduce medical risk for SOF during Grey Zone operations.

A Novel Review of 54 Cases of Prolonged Field Care

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Background: Prolonged field care (PFC) is field medical care applied beyond doctrinal planning time-lines. As current and future medical operations must include deliberate and contingency planning for such events, data are lacking to support efforts. A case review was conducted to define the epidemiology, environment, and operational factors that affect PFC outcomes.

Methods: A survey distributed to U.S. military medical providers solicited details of PFC encounters lasting more than 4 hours and included patient demographics, environmental descriptors, provider training, modes of transportation, injuries, mechanism of injury, vital signs, treatments, equipment and resources used, duration of PFC, and morbidity and mortality status upon delivery to the next level of care. Descriptive statistics were used to analyze survey responses.

Results: Surveys from 54 patients treated during 41 missions were analyzed. The PFC provider was on scene at time of injury or illness for 40.7% (22/54) of cases. The environment was described as remote or austere for 96.3% (52/54) of cases. Enemy activity or weather also contributed to need for PFC in 37.0% (20/54) of cases. Care was provided primarily outdoors (37.0%; 20/54) and in hardened non-medical structures (37.0%; 20/54) with 42.6% (23/54) of cases managed in two or more locations or

transport platforms. Teleconsultation was obtained in 14.8% (8/54) of cases. The prehospital time of care ranged from 4 to 120 hours (median 10 hours), and five (9.3%) patients died prior to transport to next level of care.

Discussion: Prolonged field care in the prehospital setting is a vital area of military medicine about which data are sparse. This review was a novel initial analysis of recent U.S. military PFC experiences, with descriptive findings that should prove helpful for future efforts to include defining unique skillsets and capabilities needed to effectively respond to a variety of PFC contingencies.

Implementation of Virtual Critical Care Consultation Service as an Adjunct to Prolonged Field Care

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Background: Consultation is a force multiplier, projecting expertise to settings where none exists. The purpose of the Virtual Critical Care Consultation (VC3) service is to provide such expertise to military providers, both stateside and deployed. This service is particularly relevant in the setting of Prolonged Field Care (PFC), where medics are responsible for the provision of care to patients not suited to immediate evacuation.

Methods: Standard operating procedures and protocols were developed using input and guidance from subject matter experts with operational and critical care backgrounds. Phone and email systems with a single contact number/address were developed. Critical care consultants took calls according to scheduled shifts. After publicizing this capability, VC3 was used as the specialty consultant feature in several Special Operations Forces (SOF) exercises. The contact information was also made available to deployed SOF units. We surveyed medics and consultants from the first 21 exercises and 4 real-world encounters to assess issues with the service and impact of recommendations.

Results: 8/60 participants who utilized the service responded to the survey (13% response rate) – all described “no difficulties” in reaching a provider. Additionally, all respondents felt the recommendations improved their management plan, were appropriate for their level of training, and were not difficult to implement following the call. Exercises averaged 3.6 calls per event (76 calls total), with 3.3 management recommendations per call. All consultants rated the quality of the clinical questions as appropriate for consultation (6/6).

Conclusion: VC3 is low-cost, low-tech telemedicine solution that integrates well into PFC, is immediately available, and can improve the provision of care by SOF medics.

Real World Experience of Prolonged Field Care in an Austere Environment

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This presentation is a review of an experience in emergency and long term medical care by SOF medical providers in an austere environment. The medical team included 2 x SF Medical Sergeants (18D) and 1 BN Surgeon (Emergency Medicine physician) or 1 BN PA. We provided acute and long term convalescent medical care for vetted partner forces in a remote, austere environment. Our facility was in a small camp that was approximately 100 kilometers from the nearest hard structure hospital, located in a desert with no roads, accessible only by air and ground vehicles equipped with off-road tires. We had no reliable air evacuation assets, and ground evacuation required a 4 hour drive through rocks and desert with no roads, to a local hospital with one part-time general surgeon, no CT scanner and minimal blood banking capability. The other option in-lieu of air assets was to drive 8 hours to the nearest large city with a trauma center. We started with a standard SF-ODA medical load-out but had to expand our capabilities due to multiple MASCALS and lack of reliable evacuation or access to host-nation medical assets. Significant improvements included upgrading the walking blood bank program to regular blood-banking services provided by a U.S. Army blood-banking program, and bringing forward portable X-ray and lab capability resulting in an effective Role 1 with many Role 2 capabilities.

Conclusion: In six months our 3-man medical team cared for several hundred patients from the SF-ODA, enablers, partner force, host-nation forces and coalition forces. In many cases, we cared for the partner force patients for several weeks. This experience both validated Special Forces medical training, as well as suggested areas of improvement and further development, including surgical stabilization, prolonged field care, ultrasound-guided regional anesthesia, physical therapy techniques and management of basic behavioral health conditions.

Manikin Human Patient Simulator Training: An End-User Survey of Special Operations Medics

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Background: Human patient simulators (HPS) are widely used in DOD training and are believed to help enhance medical education. Manikin HPS devices allow for performance of common field medical interventions, e.g. cricothyrotomy, while providing realistic feedback features such as bleeding and vital signs. This study surveyed special operations medics for feedback on the HPS features they feel most enhance their medical training and deployment preparation.

Methods: 518 US Army Special Operations Command (USASOC) and US Special Operations Command (USSOCOM) medics were surveyed between April and October of 2014 at Fort Bragg, of which 376 completed full surveys with valid responses. Surveys contained 102 total variables which were divided into three categories (general characteristics, procedures, and injuries) and assessed on a five-point bipolar Likert scale. The data sets were analyzed both together and as separate groups via Student's T-Tests. The results were then compared for significant variance from variable-based aggregate mean scores.

Results: Features that received high scores, over 4.5/5, corresponded closely with pillars of the Tactical Combat Casualty Care curriculum and Basic Life Support. Also highly valued was patient realism with regards to anatomy and feedback. USASOC and USSOCOM medics agreed on importance in over 90% of

the variables. Discordant responses were generally related to extended and definitive care procedures as well as wound management, which were rated more highly by USSOCOM medics.

Discussion: Overall, the skills most valued coincide with difficult to replicate lifesaving procedures, such as cricothyrotomy, chest tubes and wound packing. Features such as prerecorded sounds, gender, automated movements, bowel sounds, and defibrillation were rated lower. The results of these surveys may help define the use of HPS devices in military field medical training, as well as guide future development and procurement of manikin HPS devices for advanced medical training of the special operations combat medics.

Stress Induced Hypogonadal Male Condition: Are Operators Susceptible?

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Endocrine dysfunction can manifest in many ways, to include fatigue, mood disturbance, sleep disruption, altered sexual health and reduced exercise tolerance. Studies of reproductive function in male athletes have identified an exercise stress induced disruption of the hypothalamic pituitary (HP) system. The development of such changes has been termed “exercise hypogonadal male condition” (EHMC). Retrospective and prospective studies have documented lower circulating levels of testosterone (~50-85% of age matched, non-exercising men). No change in luteinizing hormone concentration or pulse generation is exhibited. Endocrine function in male athletes has been further marked by alterations in prolactin secretion and reproductive function including decreased libido, spermatogenesis, and decreased sperm motility. Psychological stress associated with high risk activities (e.g. military training, sky diving, bungee jumping) has also been reported to result in acute decreases in testosterone and increases in cortisol and prolactin. Similar to EHMC, luteinizing hormone is not suppressed. Research suggests long term effects of chronic exposure to these activities results in alterations of the HP axis. Endocrine stimulation testing has previously been used to provide a greater understanding of HP regulation given baseline values are not reliable for the determination of stress induced HP end organ dysfunction. Endurance athletes exhibit altered responses to thyrotropin releasing hormone (TRH) stimulation as indicated by increased thyroid stimulating hormone or prolactin secretion. Mild thyroid impairment in weightlifters utilizing anabolic steroids has been identified by an increased response of TSH to TRH with a concomitant decrease in total liothyronine. Baseline values of thyroid function were within laboratory ranges; thus highlighting a possible role for stimulation testing in the diagnostic process. A case series will be presented to highlight endocrine dysfunction in males uncovered through endocrine stimulation testing. Relevance of understanding similar stress induced alterations in endocrine dysfunction will be discussed as it relates to Special Operations Forces.

Novel Potassium Sorbent with Hollow-fiber Technology as a New Treatment for Severe Hyperkalemia in Austere Medicine

Phillip P. Chan, MD, PhD, CEO of CytoSorbents Corp, Monmouth Junction, NJ

Background: Severe hyperkalemia is common in polytraumatic combat injuries, and is further complicated by rhabdomyolysis, dehydration, and renal failure. Untreated severe hyperkalemia can result in dangerous cardiac arrhythmias and sudden death. Unfortunately, because of the logistic challenges of dialysis, there are no rapid, definitive treatment options for severe hyperkalemia available in austere environments and during prolonged field care. Aggressive hydration with loop diuretics, oral

potassium sorbents, calcium, and glucose and insulin are suboptimal temporizing treatment strategies. More effective definitive therapies that can be implemented in the field are needed.

Methods: We designed and synthesized cationic sequestering porous polymers to selectively remove potassium ions from blood. In vitro recirculation assays with plasma and whole blood studies were used to screen polymers that were optimized for potassium binding and calcium preservation as measured by the Radiometer ABL90 Flex blood gas analyzer. We combined these potassium adsorbing polymers with hollow-fiber membrane technology to create a novel potassium-reducing hemoperfusion prototype.

Results: Here we report the development of high capacity potassium adsorbing polymers that reduced the levels of potassium ions in porcine blood from severe hyperkalemic levels (8.0 mEq/L) to clinically normal levels. A reduction of ~50% was reached by ~1 hour and maintained for duration of the experiment (6 hours). The calcium ion levels remained unchanged during the entire time course of the experiment.

Discussion: Here we demonstrate proof-of-concept of a novel treatment for severe hyperkalemia using a hemoperfusion device consisting of potassium sorbent and hollow-fiber membrane technologies. As a simple blood in, blood out device that does not require a dialysis machine, dialysate, or replacement fluid, this device represents a potentially effective, medic-implemented treatment for severe hyperkalemia in far forward combat situations, delayed evacuation, and prolonged field care. Studies using the devices in a porcine model of hyperkalemia are in progress.

Potassium Adsorbing Polymer Technology Creates New Far-Forward Peritoneal Treatments for Severe Hyperkalemia

Phillip P. Chan, MD, PhD, CEO of CytoSorbents Corp, Monmouth Junction, NJ

Background: Severe hyperkalemia has been recognized as a life-threatening complication in combat causalities since World War II. Because severe hyperkalemia can lead to sudden cardiac death, field medics will need better treatment options to treat this condition in austere environments. Here we describe novel polymers that can bind and remove potassium from peritoneal fluid as a novel strategy to treat severe hyperkalemia in the field.

Methods: We designed and synthesized cationic sequestering porous polymers to selectively remove potassium ions from blood. In vitro plasma and whole blood studies were used to screen polymers that that were optimized for potassium binding and calcium preservation as measured by the Radiometer ABL90 Flex blood gas analyzer. We have developed prototype in-line cartridges and surgical mesh packs containing these potassium adsorbing polymers that are capable of either continuously filtering dialysate, or being placed directly into the abdominal cavity, respectively.

Results: We report the development of prototype devices designed to treat severe hyperkalemia through either sorbent-enhanced peritoneal dialysis or through abdominal packing with potassium-binding surgical mesh. This approach takes advantage of the massive surface area of the peritoneal cavity through which potassium can be extracted from the body. Proof-of-concept in vitro data on the ability of these devices to bind potassium will be presented.

Discussion: The development of treatments for severe hyperkalemia that do not require blood purification would represent a major advance in treatment. The removal of potassium from the peritoneal cavity via either a peritoneal dialysate potassium filter or an implantable potassium-binding

mesh, represent promising strategies. This technology would avoid many of the complexities of standard dialysis – the current definitive treatment of hyperkalemia. We hypothesize that reducing potassium levels in peritoneal fluid via these devices will significantly reduce systemic blood levels of potassium to normal levels. Future in vivo animal studies are pending.

Application of the iTClamp™ in Conjunction with Hemostatic Agents for Control of Lethal Hemorrhage in Swine

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2) Department of Surgery, Naval Medical Center, Portsmouth, Virginia

Background: Exsanguinating hemorrhage continues to be the leading cause of preventable battlefield death and roughly one in five are due to junctional injuries that are not amenable to traditional tourniquet techniques. TCCC recommends packing a junctional wound with gauze, applying direct pressure for 3min, then securing with an external pressure dressing. However, this method is time consuming, which can be problematic in Special Operations. Recently, iTClampTM and XStat® sponges have been FDA approved, but no studies to date have explored the efficacy of iTClamp in conjunction with XStat or Combat Gauze® compared to traditional Combat Gauze with pressure dressing.

Methods: Swine (N=31) were anesthetized and a 6mm femoral arterotomy was followed by a 45 second free bleed, then iTClamp was applied in isolation (iT, n=8) or in conjunction with Combat Gauze (iTCG, n=8) or XStat (iTXS, n=8) packing and monitored for 60min. Combat Gauze packing with pressure dressing (CGPD, n=7) served as the control. Data were analyzed using ANOVA and non-parametric statistics at $p<.05$.

Results: Even when deducting the 3min of direct pressure, CGPD was significantly slower in application than iTCG, which was significantly slower than iT or iTXS. Survival was 100% for iT and iTCG, 88% for iTXS, and 86% for CGPD. Initial hemostasis was achieved in 100% of CGPD, 88% of iT, 75% of iTCG, and 63% of iTXS. Rebleed rates were 86% for iT, iTCG, and CGPD; and 75% for iTXS. Heartrate was similar between groups across time. Respiration rate was significantly lower for CGPD for the initial 25min, then was similar to other groups.

Discussion: iTClamp, in isolation or in conjunction with XStat or Combat Gauze, was faster in application time than traditional gauze packing plus pressure dressing, with similar outcomes. These findings highlight the life-saving potential of iTClamp for treating junctional wounds during Special Operations.

Point-of-Care Ultrasound for Detecting Elevated Intracranial Pressure in the Field

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Background: Far-forward, medical personnel lack portable, easy-to-use diagnostic devices to help detect and manage severe head trauma. One manifestation of head trauma requiring specific therapy is

increased intracranial pressure (ICP). Ultrasound measurement of optic nerve sheath diameter (ONSD) is correlated with increased ICP. Very few emergency medicine physicians, surgeons, or pre-hospital personnel are trained in the image acquisition necessary to measure optic nerve sheath diameter.

Method: We have devised a system that will acquire B-mode images using a hand-held, single-crystal ultrasound device (Interson, Inc.) that can transmit images to a tablet or laptop computer over USB. As images are streamed to the computer, the image that best matches a statistical model of the expected appearance of an ideal optical nerve image can be automatically chosen for analysis. We have demonstrated (1) using superpixel preprocessing to delineate regions having consistent ultrasound features, (2) applying intensity and texture analysis of those superpixels to estimate their probability of being contained within the optic nerve, (3) integrating a spatial statistical prior model to identify the collection of superpixels that comprise the optic nerve, and (4) estimating the diameter of the optic nerve sheath at 3mm posterior to the globe of the eye. Work is underway to integrate this system and use 3D printing to construct ultrasound compatible anatomic models with simulated optic nerves having 4mm, 5mm, and 6mm diameters to test the sensitivity and specificity of the system.

Results: Will be available in early 2017 for presentation at the meeting.

Discussion: Preliminary successes indicate that advance ultrasound, computer vision, and machine learning methods can be combined to define a highly portable system that can automatically detect high-quality ultrasound images of the optic nerve and assess optic nerve sheath diameter for in-field detection of elevated ICP.

Prehospital Administration of Tranexamic Acid by Ground Forces in Afghanistan

LTC Guyon Hill, San Antonio Medical Center; MAJ Steven G. Schauer, US Army Institute of Surgical Research; MAJ Michael D. April, San Antonio Military Medical Center; MAJ Jason F. Naylor, 28th Combat Support Hospital; MAJ Jonathan Wiese, Carl R. Darnall Army Medical Center; LTC Cord W. Cunningham, 1st Cavalry Division; Col Mark A. Antonacci, San Antonio Military Medical Center

Background: The CRASH-2 multinational randomized controlled trial demonstrated that Tranexamic acid (TXA) reduces overall mortality and death secondary to hemorrhage. This intervention is time-sensitive. As such, the Tactical Combat Casualty Care (TCCC) Guidelines now recommend use of this low-cost, safe intervention during the early stages of resuscitation of patients with possible hemorrhagic shock (i.e. documented hypotension), penetrating trauma to the thorax or trunk, or an extremity amputation.

Objective: To describe prehospital administration of TXA by ground forces in the Afghanistan combat theater.

Methods: We obtained data from the Prehospital Trauma Registry (PHTR). We linked subjects to the DoD Trauma Registry (DODTR), when available, for outcome data upon reaching a fixed-facility.

Results: Out of the 737 subjects during the time-period, 272 met criteria for inclusion. The majority were battle injuries (97.8%, n=266). There was a total of 51 (7.2%) subjects administered TXA throughout the study period. The low rates of adherence persisted across subgroup analyses.

Conclusion: Adherence with TXA administration was low despite emphasis in the guidelines. This is likely multifactorial. Future research should examine the development of training and technology to improve prehospital TXA use.

The Pediatric Resuscitative Thoracotomy During Combat Operations in Iraq and Afghanistan

LTC Guyon Hill, San Antonio Medical Center; MAJ Steven G. Schauer, US Army Institute of Surgical Research; MAJ Michael D. April, San Antonio Military Medical Center; CPT R. Erik Connor, San Antonio Military Medical Center; COL John S. Oh, Walter Reed Army Medical Center

Background: The non-traditional nature of combat operations in Iraq and Afghanistan during the recent conflicts has led to a number significant civilian casualties. Pediatric patients present unique challenges due to differences in size and physiology compared to the adult population typically seen among combatants. There is a relative dearth of data on emergency care for the pediatric trauma patient in this setting. We seek to describe the experiences of pediatric subjects underdoing resuscitative thoracotomy in the combat environment.

Methods: We queried the Department of Defense Trauma Registry (DODTR) from 2007 to 2016 for all pediatric subjects that underwent a resuscitative thoracotomy. We excluded subjects if the procedure did not have a documented location or occurred after leaving the Role III emergency department (i.e. operating room).

Results: During the study period, there were a total of 3,439 pediatric trauma admissions to Role III facilities which accounted for 8.0% of total admissions. We identified 13 thoracotomy procedures (8 in the ED, 5 pre-Role III/pre-hospital) during the study period. In this cohort, the average age was 9.3 years (range 0-15 years). Most were male (n=10, 76.9%). The majority (n=9, 69.2%) sustained injuries as non-combatant collateral damage. The average composite ISS score was 23.2 (range 1-75).

Conclusions: In this cohort, 4 patients (2 MVC, 2 blast) out of the 13 individuals that had a resuscitative thoracotomy performed survived to hospital discharge. The utility of this resuscitative procedure remains poorly defined currently with larger data sets still necessary.

Junctional Tourniquet Use During Combat Operations in Afghanistan

LTC Guyon Hill, San Antonio Medical Center; MAJ Steven G. Schauer, US Army Institute of Surgical Research; MAJ Michael D. April, San Antonio Military Medical Center; MAJ Andrew D. Fisher, 75th Ranger Regiment; LTC Cord W. Cunningham, 1st Cavalry Division; LTC Jennifer Gurney, US Army Institute of Surgical Research

Introduction: Hemorrhage is the leading cause of potentially preventable death on the battlefield. While the resurgence of extremity tourniquets revolutionized hemorrhage control in combat casualties in the recent conflicts, junctional hemorrhage continues to have a high lethality. Junctional tourniquet devices offer a mechanism to address this capability gap. The success of these devices in the combat setting is unclear given the dearth of data.

Case Data: We acquired the cases from the Prehospital Trauma Registry (PHTR) and the Department of Defense Trauma Registry (DODTR). We identified 12 uses of a junctional tourniquet device. We excluded one case which entailed use as an improvised pelvic binder. Of the remaining 12 cases of device use, 7 had documented success of hemorrhage control, 3 failed to control hemorrhage, and 2 were missing documentation regarding success or failure.

Conclusions: We report 12 cases of prehospital use of junctional tourniquets in Afghanistan. This case series suggests that this device may have some utility in achieving hemorrhage control strictly at junctional sites (e.g., inguinal creases). However, it also highlights that this device may be ineffective in instances of significant tissue damage, sites proximal to the crease or the axilla. This series also suggests there remains a need for improvements in technology and training.

QuikClot (TM) Combat Gauze Use by Ground Forces in Afghanistan

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Background: Hemorrhage is the leading cause of potentially preventable death on the battlefield. Tourniquets revolutionized hemorrhage control on the battlefield but come with significant limitations. The military fielded QuikClot TM Combat Gauze (QCCG) in 2008 to replace previous generations of pro-coagulant gauze that had less than desirable adverse-effects. Civilian-based studies demonstrate success in hemorrhage control using QCCG prehospital. To the best our knowledge, despite nearly a decade of use, there is no published data on use by United States (US) combatant forces.

Objective: We seek to describe the use of QuikClot Combat Gauze by ground forces in Afghanistan.

Methods: We obtained data from the Prehospital Trauma Registry (PHTR). Joint Trauma System personnel linked subjects to the DoD Trauma Registry (DODTR), when available, for outcome data upon reaching a fixed-facility.

Data: Out of the 705 subjects in the PHTR during the project time period, 118 (16.7%) had documented use of QCCG. The majority of the subjects (69.5%) were Afghan partner forces. All were male. Lower extremities accounted for the most (39.2%) common anatomical site of application. QCCG administration achieved hemorrhage control in 63.6% of encounters; 8.4% of encounters documented failure to achieve hemorrhage control; the remaining encounters lacked documentation on hemostasis. The proportion of encounters with documentation of concomitant resuscitation procedures included: intravenous saline (16.9%), IV Hextend (25.4%), pressure dressing (50.0%), tranexamic acid (16.1%), and tourniquet (39.0%).

Conclusion: QCCG appears to have important use on the battlefield as a concomitant intervention for obtaining hemorrhage control. However, substantial proportions of applications fail to achieve hemorrhage control, likely due to the severity of combat-injuries not seen in other military and non-military conflicts.

Chest Seal Placement for Penetrating Chest Wounds by Ground Forces in Afghanistan

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BACKGROUND: Current Tactical Combat Casualty Care (TCCC) guidelines recommend the placement of a vented chest seal device for casualties with penetrating trauma to the chest. There are many chest seal

devices on the market and currently in use in the combat theaters. Adherence to TCCC guidelines for placement of chest seals is unknown at this time.

OBJECTIVE: To describe adherence for chest seal placement in accordance with TCCC guidelines.

METHODS: We obtained data from the Prehospital Trauma Registry (PHTR). We searched for subjects with gunshot wounds (GSW) or puncture wounds (PW) to the chest. We linked subjects to the DoD Trauma Registry (DODTR), when available, for outcome data upon reaching a fixed-facility.

DATA: This is a preliminary analysis. During the study period we identified 47 (6.7% of total casualties during the study period) subjects with GSWs to the chest and 16 subjects with blast-related puncture wounds (2.3% of total casualties) to the chest. Most chest seals placed were HALO (Chinook Medical Gear, Inc).

CONCLUSIONS: Overall rates of penetrating trauma to the chest was low. A full analysis of chest seal adherence is pending.

Phase 3 Efficacy and Safety Results of Sufentanil Sublingual Tablet 30 mcg for Management of Acute Traumatic Pain

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Background: Intramuscular (IM) morphine has been the standard-of-care treatment for acute pain in the battlefield for over 150 years. Limitations of this therapy include slow onset of analgesia, due to poorly-perfused muscles, side effects resulting from inconsistent absorption, risk of needle-stick injuries and infection. Many soldiers suffer from acute pain while waiting for intravenous (IV) access to be established and there remains a clinical need for a non-invasive, potent analgesic with predictable onset. In collaboration with the Department of Defense, a sufentanil sublingual tablet (SST) 30 mcg has been developed for treatment of moderate-to-severe acute pain in medically supervised settings. The primary objective of this study was to evaluate the safety and efficacy of the SST 30 mcg in the management of moderate-to-severe acute pain in emergency department (ED) patients.

Methods: This was a multicenter, open-label study in 76 adults presenting to the ED with acute pain due to trauma or injury. Patients must have reported a pain score of ≥4 on an 11-point numerical rating scale before first dose of study drug could be given. Primary efficacy variable was the time-weighted summed pain intensity difference to baseline over the 1-hour study period (SPID1). Safety was assessed via vital signs and adverse event reporting (AEs).

Results: A total of 76 patients were enrolled; mean age 42 years, 61% were male. Baseline pain intensity (mean) 8.1/10 (“severe” pain). Substantial reductions in Pain Intensity (mean 2.9/10) within the first hour were recorded with 4 patients in total terminating early due to inadequate analgesia. No AEs were reported in 60/79 (79%) patients, but the most frequently reported were nausea (9.2%) and somnolence (5.5%).

Discussion: Efficacy and tolerability results from this study suggest that sufentanil 30mcg tablets dispensed sublingually may offer a viable alternative to IM or IV analgesia in emergency trauma settings.

Education in a Far Forward Blood Transfusion Concept in the Danish Special Operations Forces

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Background: On the battlefield, hemorrhage is still the leading cause of death in the group of potentially salvageable fatalities. To oppose this, several countries have introduced Far Forward Blood transfusion (FFBT). In Denmark, this is not allowed due to concerns that the SOF operators do not have the experience and skills to perform a blood transfusion in a safe way. We wanted to investigate whether it was possible in a one-day course to educate non-medic SOF Operators in a FFBT concept to a level where the non-medic SOF operator could assist a medic SOF Operator in performing a blood transfusion in a safe and correct way according to a pre-defined protocol.

Method: Danish SOF operators. Education topics: 1) Theory (Blood types. Blood transfusion. Transfusion transmitted diseases. Transfusion sickness syndrome. RDCR. Traumatic hemorrhage. Protocol for FFBT.). 2) Practical skills (Blood type testing. Blood collection from buddy. Marking blood bag. Donor/receiver identity/blood type identification) Evaluation: 55 question multiple choice pretest, posttest (same questions) and control of practical skill, all performed on the education day. Tests were validated through a Delphi process. Twelve SOF operators participated (4 medics; 8 non-medics).

Results: All non-medics except one and all medics managed the theoretical posttest with an acceptable result and all did well in the practical skill control. The overall posttest result in the non-medic group was 88+-7% (mean+-SD) correct answers and this was an absolute improvement from the pretest of 49+-10% (mean+-SD). The overall theoretical posttest result in the medic group was 90 +-5% (mean+-SD) and this was an absolute improvement of 21+-13% (mean+-SD).

Conclusion: We managed to educate non-medic SOF operators during a one day course to a level where they are assumed to be able to assist a medic SOF operator perform FFBT in a safe way and with proper theoretical knowledge.

Prehospital Procedures Performed on Pediatric Trauma Patients in Iraq and Afghanistan

LTC Guyon Hill, San Antonio Medical Center, Dell Children's Hospital; MAJ Steven G. Schauer, DO, US Army Institute of Surgical Research, MAJ Michael D. April, MD PhD, San Antonio Military Medical Center; COL (ret) Robert A Delorenzo, MD MSM MSCI - University of Texas Health Science Center at San Antonio

Background: The complex nature of the current conflicts has led to civilian casualties, including children. Management of the pediatric trauma patient presents multiple unique challenges including limited training, lack of prior experience, provider apprehension and unique equipment requirements.

Methods: We queried the Department of Defense Trauma Registry (DODTR) for all pediatric subjects admitted to US and Coalition fixed-facility hospitals in Iraq and Afghanistan from January 2007 to January 2016. We excluded subjects 16 and older to eliminate combatants.

Data: This is a preliminary analysis with a full analysis pending. There were 3180 that met inclusion criteria. In the <2 years age group (5.8%, n=183) the majority were non-battle injuries (34.4%), the most common mechanism of injury was burn (39.9%), the majority were in Operation Iraqi Freedom (OIF) (52.5%), the majority discharged alive (88.0%) with an average injury severity score (ISS) of 10.6 (range 1-50). In the 2-8 years age group (38.1%, n=1213) the majority were battle injuries (53.7%), the most

common mechanism of injury was explosive (38.7%), the majority were in Operation Enduring Freedom (OEF) (60.8%), the majority discharged alive (89.2%) with an average ISS of 11.6 (range 1-75). In the 8-15 years age group (56.1%, n=1784) the majority were battle injuries (72.3%), the most common mechanism of injury was explosive (48.1%), the majority were in OEF (74.7%), the majority discharged alive (91.0%) with an average ISS of 12.8 (range 1-75). During this time period, providers performed 18 cricothyrotomies, 196 intubations, 12 central lines, 43 cardiopulmonary resuscitation attempts, 178 intraosseous lines, 493 intravenous lines, 448 IV fluid administrations, 18 extremity splints, 250 extremity tourniquets, 29 needle decompressions, 27 chest tubes, 872 wound dressings, and 52 hemostatic dressings.

Conclusions: Prehospital providers must be prepared to resuscitate trauma patients of all ages, including pediatric patients. In this data set the most common interventions related to hemorrhage control and circulatory support.

Prehospital Medications Administered to Pediatric Trauma Patients in Iraq and Afghanistan

LTC Guyon Hill, San Antonio Medical Center, Dell Children's Hospital; MAJ Steven G. Schauer, DO, US Army Institute of Surgical Research; MAJ Michael D. April, MD PhD, San Antonio Military Medical Center; COL (ret) Robert A. Delorenzo, MD, MSM, MSCI, University of Texas Health Sciences Center at San Antonio

Background: The complex nature of the current conflicts has led to civilian casualties, including children. Management of the pediatric trauma patient presents unique challenges including limited training, lack of prior experience, and unique equipment requirements.

Methods: We queried the Department of Defense Trauma Registry (DODTR) for all pediatric subjects admitted to US and Coalition fixed-facility hospitals in Iraq and Afghanistan from January 2007 to January 2016. We excluded subjects 16 and older to eliminate combatants. We separated subjects by age: <2 years, 2-8 years, 8-15 years.

Data: This is a preliminary analysis with a full analysis pending. There were 3180 subjects that met inclusion criteria. In the <2 years age group (5.8%, n=183) the majority were male (62.3%), the majority were non-battle injuries (34.4%), the most common mechanism of injury was burn (39.9%), the majority were in Operation Iraqi Freedom (OIF) (52.5%), the majority discharged alive (88.0%) with an average ISS of 10.6 (range 1-50). In the 2-8 years age group (38.1%, n=1213) the majority were male (68.3%), the majority were battle injuries (53.7%), the most common mechanism of injury was explosive (38.7%), the majority were in Operation Enduring Freedom (OEF) (60.8%), the majority discharged alive (89.2%) with an average ISS of 11.6 (range 1-75). In the 8-15 years age group (56.1%, n=1784) the majority were male (83.5%), the majority were battle injuries (72.3%), the most common mechanism of injury was explosive (48.1%), the majority were in OEF (74.7%), the majority discharged alive (91.0%) with an average ISS of 12.8 (range 1-75). Medications administered by category included: antibiotic (209), anti-emetic (57), ketamine (132), mannitol (11), narcotic analgesics (587), paralytics (228), sedatives (228).

Conclusions: Prehospital providers must be prepared to resuscitate trauma patients of all ages, including pediatric patients. In this data set the most common medications administered were narcotic pain medications.

Hyperbaric Medicine Update

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PROBLEM STATEMENT: Undersea Hyperbaric Medicine (UHM) is an American Board of Medical Specialties subspecialty that is supported by the American Board of Emergency Medicine and the American Board of Preventive Medicine. In the United States, from 1994 to 2014, the number of hyperbaric chamber sites expanded from approximately 200 to over 1,200, a growth rate during that time period of over 500%. In carefully selected patients with certain diagnoses, hyperbaric oxygen (HBO2) treatment can save life, limb, and eyesight. Unlike most other specialties, exposure to the basics in UHM is not offered at many medical schools or in many residencies.

TOPIC: The Undersea & Hyperbaric Medical Society maintains a list of diagnoses, which has grown over the decades. To be placed on the list, data from research and experience are carefully assessed by panels of experts in multiple specialties, not just UHM. In recent years the list has grown; currently it contains 14 diagnostic categories. Carefully selected patients with diagnoses on this list, who have failed to improve in a timely manner with other indicated interventions, may be considered for HBO2 treatment consultation (bearing in mind that not all HBO2 consultations will necessarily be determined to be appropriate for HBO2 treatment).

APPLICATIONS: In carefully selected patients, HBO2 treatment can be lifesaving. An aspect of this poster is looking at some of the parameters used in this careful patient selection process. Since UHM fundamentals are not offered at all medical schools or in many residencies, the medical knowledge presented here can assist physicians, nurses, or other professionals in determining whether their patient could benefit from an HBO2 consultation.

Combat Trousers as Effective Improvised Pelvic Binders: A Comparative Cadaveric Study

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Introduction: Military forces are increasingly operating in small groups in austere, remote and hostile environments with limits on volume and weight of equipment carried. Improvised explosive devices (IEDs) and landmines are an ever-present threat that can cause pelvic fractures producing catastrophic haemorrhage. This cadaveric study compared the intra-pelvic pressure changes that occurred with the application of an improvised pelvic binder adapted from the combat trousers worn by British military personnel to a commercially available trauma pelvic orthotic device (TPOD)

Methods: Six unembalmed cadavers (three male, three female) were used to simulate an unstable pelvic fracture (OA/OTA 61-C1) by dividing the pelvic ring anteriorly and posteriorly. A 3-4cm manometric balloon filled with water was placed in the retropubic space and connected to a 50mL syringe and water manometer via a 3-way tap. A baseline pressure of 8cmH2O (average central venous pressure) was set. The TPOD and Combat Trouser Binder (CTB) were random-sequence applied to each cadaver and the steady intra-pelvic pressure changes recorded. Statistical analysis was performed using

the Mann-Whitney U test to determine impact on the intra-pelvic pressure of each intervention compared to baseline.

Results: The median steady intra-pelvic pressure achieved after application of the CTB was 16cmH2O, significantly greater than the baseline pressure ($p<0.05$). The TPOD binder produced steady intra-pelvic pressures of 18 cmH2O ($p<0.05$). There was no difference between the steady median pressures achieved with either intervention ($p>0.05$). The CTB is therefore comparable to the TPOD.

Conclusion: Pelvic injuries are increasingly common in modern theatres of war. This is a novel, rapidly deployable yet effective method of pelvic binding adapted from the clothes the casualty is already wearing. This technique may be employed in austere environments to tamponade and control intra-pelvic haemorrhage.

Capnometry-Guided Respiratory Intervention: A Potential Resilience-Building Intervention for Military Personnel at Risk for Development of PTSD

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Background: Sensitivity to carbon dioxide (C02) challenge is recognized as a specific biomarker for panic disorder (Nardi et al, 2009). The intersecting symptoms of PTSD and panic have led to evidence of similar reactivity to C02 challenge in civilian PTSD subjects (Muhtz et al, 2011) as well as a potential predictor of post-deployment PTSD in soldiers (Telch et al, 2012).

Method: This emerging literature raises the question of whether pre-deployment C02 challenge can serve as a potential screen for subsequent PTSD risk. Given that both PTSD and panic show similar physiological reactivity, a new respiratory intervention that normalizes dysfunctional respiratory physiology holds promise. Freespira (FDA-cleared) has an established evidence-base for the treatment of panic symptoms. It comprises a custom sensor that measures respiratory rate and exhaled end-tidal C02. Feedback of these measures in a structured protocol is provided via an app running on a tablet computer. Over four weeks, subjects are trained to normalize their respiratory physiology using brief, at-home, twice-daily sessions. Session data is remotely viewable by the provider to assess progress and compliance. Prior clinical trials for panic disorder reported 68% panic attack-free and clinically significant improvement in 93% of subjects one-year post-treatment (Meuret et al, 2008). While a VA clinical trial is underway for treatment of PTSD, the potential of employing the intervention during pre-deployment as a preventive, resilience-building strategy may have special merit for adoption in special-forces settings. The ease-of-use, safety, and skill-building aspects of the intervention are facilitating features; additionally, physiological training may be more acceptable to soldiers than psychotherapeutic approaches.

Discussion: This presentation will review the respiratory physiology of panic, the literature concerning C02 challenge in PTSD and panic, and the evidence base for treating panic symptoms by normalizing dysfunctional breathing. Potential applicability of the intervention in pre-deployment training will be explored.

Efficacy of Abdominal Aortic Junctional Tourniquet-Torso Plate in a Lethal Model of Non-Compressible Torso Hemorrhage

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Background: Despite advances in the management of non-compressible torso hemorrhage (NCTH) and hemorrhage-induced cardiac arrest (resuscitative endovascular balloon occlusion (REBOA) and selective aortic arch perfusion (SAAP)), there remains a critically unmet need for devices to address NCTH in Anti-Access Area Denial theaters of operation. The Abdominal Aortic Junctional Tourniquet, when modified with an accessory pressure distribution plate (AAJT-Plate), has the potential to address this lethal injury complex in prolonged field care.

Methods: Using a lethal non-compressible torso hemorrhage model, Yorkshire swine (75-85kg) were randomized into two groups: Control or AAJT. Anesthetized animals were instrumented for physiologic telemetry. Three pressure transducers were placed to measure intraabdominal pressure (hepatic, mesentery and paracolic gutter). A left liver lobe transection was achieved laparoscopically and allowed to hemorrhage freely for 10min. At 10min, the AAJT plate was applied and inflated to an intraabdominal pressure of 40mmHg or until the maximum safe AAJT pressure was achieved. Both groups received up to 2-500mL boluses of Hextend. At 30min post application, the AAJT was deflated but windlass left tightened. Animals were observed for a pre-hospital time of 60min. Survival was the primary endpoint.

Results: Compared to control (n=4), survival was higher in AAJT (n=3; 100% vs 50%), accompanied by less post injury shed blood (2017±112ml vs 3298±146ml; $p<0.01$) and higher peak abdominal pressure (34.0±10mmHg vs 9.0±3.8mmHg). Both groups similarly exhibited elevated terminal lactate (AAJT=9.0±8.8mmol/L, Control=6.7±3.0 mmol/L).

Discussion: These findings demonstrate the potential for AAJT-Torso Plate to be a novel, non-invasive intervention to greatly improve survival and reduce post injury blood loss following NCTH. Unlike REBOA and SAAP, AAJT can be rapidly applied with minimal skill and training, and allows for arterial flow below the level of application to reduce metabolic dyshomeostasis. Studies are ongoing to determine AAJT-Plate impact on physiology post-injury with damage control resuscitation and critical care.

Evaluation Model for a Military Expedition Performance Environment

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Background: Previous studies have shown an increased risk in mortality of organized ‘extreme’ mountain expeditions.1 Social and team interaction are believed to be important factors that can have a negative impact on this unwelcome outcome of ‘team performance’. Applying a model, which has been tested in other sport disciplines2, to evaluate eight major factors for team performance in extreme mountaineering can be a great tool to identify their impact plus to monitor individual and team progression in a ‘military expedition performance environment’ (MEPE).

Methods: Retrospective data collected from an expedition to Mt. Manaslu Nepal (8163m), in spring 2016, of 25 Mountain specialists from the Royal Netherlands Marine Corps (MS-RNLMC). Analyzing the effect on individual and team performance: physical parameters (pre- and post- biometry measurements, maximal exercise stress test and spirometry, periodic heart rate frequency, pulse oximetry urine osmolality, rate of perceived exertion, (altitude) illness incidence, (inter)personal questionnaires (evaluating physical, cognitive and emotional status, social cohesion, aspects of planning, organization and coaching) and environmental factors (altitude, temperature).

Results: Full data analysis is in process at the time of writing. Completion is aimed for early 2017. Interim analysis demonstrate 29 expedition doctor consultations, clinical diagnoses: 10 gastro-enteritis, 10 altitude illness (Lake Louise Score: 5 ≤5; 5 >5; including 1 Sherpa with clinical HACE), 3 respiratory infections, 1 frostbite gr. 1, 1 migraine, 3 other specified. 7 Climbers successfully summited. One ground evacuation to lower altitude was executed by an established MS-RNLMC Mountain Rescue Team (MRT).

Discussion: The preliminary data describes an expedition performance outcome in which further results should provide more information about method efficiency and possible impact of each MEPE influencing factor as mentioned in Methods. In the aim to develop an evaluation model as a useful tool it can contribute to risk reduction and safety in future expeditions.

References:

1. Shlim DR, Gallie J. (1992). The causes of death among trekkers in Nepal. Int J Sports Med 13 Suppl 1,S74-6.
2. Pain MA, Harwood C. (2007). The performance environment of the England youth soccer teams. J Sports Sci 25,1307-24.

Left Of Bang Interventions in Trauma - An Opportunity to Protect High Risk Warfighters

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The history of the last 100 years of combat casualty care has demonstrated the move from a geographic to a temporal concept of operations. This focus on time has led to a dramatic reduction in the interval between wounding and medical care through the use of high-speed tactical medical evacuation and forward mounting of medical assets. The question we face now is: how to improve from here? In Special Forces operations where timelines may be extended and timely evacuation proves challenging, how can we give our warfighters the best chance of surviving to definitive care and beyond? We propose one answer is to explore the opportunity to intervene before injury occurs in order to give our combatants the highest chance of survival and recovery afterwards; in essence, trauma prophylaxis. We are developing the conceptual and ethical framework in which innovation in this area can flourish. There are many examples of promising pre-clinical work being undertaken that could be translated into the military setting. The use of curcumin to mitigate the effects of brain injury, tranexamic acid to prime the coagulation system, statins to reduce the deleterious inflammatory response to trauma, simulation of hypovolaemia to condition the vascular response to haemorrhage, and beta-hydroxy-beta-methylbutyrate to mitigate post traumatic sarcopaenia are just a few examples of agents that have the potential to reduce morbidity and mortality after trauma if given before it even happens. This approach has several important conceptual challenges including patient selection, risk-benefit analysis, and

evidence base but none are insurmountable. Of all roles within the military, Special Forces operators are likely to be the group most likely to benefit from left-of-bang trauma prophylaxis due to the high risk operations they undertake, their temporal risk profile, and the potentially challenging evacuation conditions.

POSTER PRESENTATIONS

Don't Let Chikungunya Get Ya! An Emerging Disease Threat for US Military

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Introduction: Chikungunya is a mosquito vector-borne viral disease that causes fevers, rash, and debilitating polyarthralgias. While previously a disease primarily of Africa and Europe, it is spreading throughout Central America, the Caribbean, and Florida, areas of current and future activity of United States Armed Forces.

Case Presentation: A 34 year old male operator presented to the emergency department with worsening asymmetric polyarthralgias and recurrent fevers. Six weeks prior while deployed to Guatemala, he was bitten by a mosquito and shortly thereafter developed rigors, night sweats, malaise, nausea, and headaches without photophobia or nuchal rigidity. Symptoms progressed to generalized polyarthralgias, diffuse lymphadenopathy, and erythematous rash on inner surfaces of his arms and legs. Labs at a local hospital were reportedly inconclusive. He was bedridden but improved to baseline function over the next four weeks before returning home on leave and presented to us with recurrent pain and decreased range of motion in shoulders, wrists, and ankles. While admitted, he had nightly fevers, and labs showed positive IgM and IgG titers for chikungunya.

Discussion: This case highlights a potentially devastating disease that can severely impact a unit's mission in austere, deployed settings, as well as future deployability of affected operators. Currently there is no chikungunya vaccine, forcing units to focus on limiting disease transmission. Army Regulation 40-501 does not provide guidelines on soldiers with chikungunya and implications for fitness for duty. Scholarly Question: What are the short and long term implications for an operator who contracts chikungunya regarding future medical readiness and deployability?

Conclusion: Chikungunya has a variable presentation regarding severity, duration, and recurrence of symptoms. Military recommendations focus on prevention; for infected operators, there are no guidelines regarding medical readiness and deployability. Given risk of recurrence and debilitating nature, these decisions should be centered on a unit's area of operation and access to medical resources.

Combat Casualty Care Research Program Investment to Close Capabilty Gaps in Tactical Combat Casualty Care

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Background: In order to advance battlefield trauma care, the Combat Casualty Care Research Program directs the investment of military research funding to innovate materiel and knowledge products in

response to user requirements. Butler et al., on behalf of the Committee on Tactical Combat Casualty Care published a "Top Ten" requirements for innovations for the future of TCCC.

Methods: We conducted a review of existing and future investments in CCC research and identified innovations which meet this call for new capabilities.

Results: We identified significant investments in blood product development, blood product use, hemostatic agents, pain control, and point of injury diagnostics which will address the most urgent requirements from the CoTCCC.

Discussion: High concordance between CoTCCC requirements and CCCRP investments are indicative of ongoing coordination and collaboration between the JTS, CoTCCC and medical research and development. In order to ensure that innovations are rapidly fielded and optimally developed to ensure relevance to the medic providing care, ongoing collaboration should be sustained.

Computer-Assisted E-FAST Exams for In-Field Triage

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Background: Far-forward, medical personnel lack portable, easy-to-use diagnostic devices to detect intra-abdominal bleeding (IAB) or pneumothorax. The Extended Focused Assessment with Sonography in Trauma (E-FAST) exam has the potential to diagnosis IAB and pneumothorax. When in-field ultrasound is conducted by experts, patient management is altered in 37% of cases. However, even after hours of training, pre-hospital personnel are not sufficiently proficient in FAST for over 48% of trauma patients. There is no currently available technology to allow medics or physicians with limited ultrasound training to perform E-FAST.

Method: Using radiofrequency (RF) data recorded at multiple transmit powers and frequencies from an ultrasound probe (Interson, Inc.) connected via USB to a laptop computer, we applied (1) multi-feature superpixel preprocessing to delineate anatomic regions in those RF data, (2) spectral coherence to detect regions of weak acoustic coupling (e.g., insufficient gel or obscuring ribs), (3) random forest classification to identify regions of interest (e.g., pooled blood), and (4) dynamic texture classification to determine the probe's general anatomic position. Preliminary studies were conducted. Ultrasound was acquired from a tissue phantom that included regions of pooled blood. Ultrasound and CT scans were retrospectively analyzed to assess automated position estimation. Also a human cadaver study was performed: sheep's blood (300 mL) was injected into a cadaver, and repeated CT images and ultrasound scans were acquired to monitor blood progression within the peritoneal sack.

Results: Preliminary results indicate 94.8% true positive pooled blood detection at 0.5% false positive rate and ultrasound probe localization that is insensitive to common anatomic variations.

Discussion: Preliminary successes indicate that advanced ultrasound, computer vision, and machine learning methods can be combined to define a highly portable system that automatically guides probe

positioning, and detects blood in the peritoneal cavity without an operator skilled in image interpretation.

Evaluation of Commercial Tourniquets for Pediatric Patients Using Simulated Extremities
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There have been many papers published recently evaluating different commercially available tourniquets for adult populations. Previous research has focused on healthy adult males. There has been a lack of published research on tourniquets in the pediatric age group because most Institutional Review Boards hesitate to approve testing painful of children. Unfortunately many recent active shooter events have involved children as well as adults.

We chose to evaluate commercial tourniquets. We chose to use limb substitutes comprised of thin wall latex tubing next to wooden dowel rods surrounded by beef enclosed in 1,000 denier cordura nylon fabric. Several diameter test limbs were constructed to simulate arms and thighs of children aging from 2 thru 12 based on measured arm and thigh diameters in a busy pediatric clinic. Blood flow was simulated by placing IV fluids in a pressure bag inflated to pressures ranging from 90 to 150mmHG Combat Application Tourniquets “CAT” (North American Rescue), SOF® Tactical Tourniquet-Wide “SOFTT-W” (Tactical Medical Solutions),TACMED K9 Tourniquet “TMK9” ” (Tactical Medical Solutions) and the SWAT-T Tourniquet “SWAT-T” (TEMS Solutions) were evaluated.

The TMK9 proved fasted and most effective on simulated pediatric extremities.

Don't Trust Morrison's Pouch!
Kyle Nielsen, DO, PGY-2 Emergency Medicine Resident CRDAMC; Jonathan Wiese, MD, RDMS, Staff Physician CRDAMC

Introduction: The portable ultrasound is an increasingly effective and efficient tool used in the hands of our special operations medics. The Focused Assessment with Sonography in Trauma (FAST) has become an important tool to identify injuries in soldiers with blunt or penetrating trauma. A complete FAST exam identifies fluid in one of four different areas; the hepatorenal recess (Morrison’s pouch), the pelvis, the perisplenic space and the pericardium. While this study was not conducted in the battlefield, its implications extend to warfighters who are increasingly utilizing ultrasound technology for rapid trauma assessment.

Case Description: 43 yo male s/p laparoscopic cholecystectomy 8 days’ prior who presented with increasing diffuse abdominal pain radiating to the R shoulder. A bedside FAST exam demonstrated a large amount of intraperitoneal free fluid with bilateral pleural effusions. Yet despite the large amount of free fluid, none was visualized within Morrison’s pouch. On admission, diagnosis of a damaged common bile duct with an intraperitoneal biloma and reactive pleural effusions was confirmed.

Discussion: In a supine patient, intraperitoneal free fluid is most likely found within Morrison’s pouch. In the interest of time and efficiency, some investigators have advocated for a single view FAST, encompassing only Morrison’s pouch. The single view sensitivity has been reported to approach that of a complete exam with a sensitivity of 82% and 87% respectively. Emergency personnel and medics operating in austere and hostile environments may be tempted to utilize such an expedited approach. In

this case, a single view would have inadequately led to a falsely negative conclusion. We recommend a complete exam encompassing all four views.

A Predictive Medical Analytics Application to Support Prolonged Field Care

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Background: Injured warfighters rely on the experience of combat medics to provide care with a limited set of available tools. However, as the United States military extends its operational areas there is an emerging need for combat medics to provide care beyond the “golden-hour”. As such, combat medics will be tasked with providing prolonged field care and en route care. Thus, a critical need emerges to leverage technology to provide decision support in the absence of medical expertise.

Methods: To address this need, Aptima, Inc. is developing the Predictive Medical Analytics Application (PMAA). PMAA is designed to support combat medics managing patients in austere environments for extended periods of time with limited resources as well as limited surgical or other medical support. PMAA offers the prolonged care provider decision support recommendations, tracks times and procedures, and reminds overextended providers when to perform recommended actions. PMAA is being developed to include a variety of machine learning-based predictive models and classifiers which serve to drive decision support algorithms that are customized and built for specific injuries and patient conditions.

Results: The results and lessons learned from developing PMAA will be presented. This will cover how the PMAA’s machine learning approach alerts the combat medic prior to significant changes in patient/casualty status, provides the visualization of trends, and generates recommendations to facilitate timely and informed decisions to improve survivability in the face of prolonged field care.

Discussion: In this presentation we will discuss: how the design and features of PMAA offers a more comprehensive approach to patient care in austere settings; how PMAA allows for integration of both current and future monitoring technologies available to combat medics; and the means by which PMAA supports continuous improvement by establishing a repository of field care cases that will be used to optimize models and analytics.

Special Operations Force Risk Reduction: Integration of Expeditionary Surgical and Resuscitation Teams

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Background: Risk of combat trauma in Special Operations Forces (SOF) is a constant factor in operational planning. The proximity of Damage Control Surgery (DCS) and robust medical evacuation platforms

within the “Golden Hour” of trauma has been shown to decrease mortality in combat trauma. Although these are not new concepts, the availability and integration of these medical assets remains very limited in a nonconventional environment.

Methods: “Medical Risk Scale” (MRS) was collected prospectively and retrospectively for SOF operations involving the newly formed ERST-EA. The MRS is a planning matrix used by SOF commanders to evaluate operational risk. The MRS is composed of “time to ER” as well as “time to DCS.” Resulting in “Low,” “Moderate,” “High,” and “Very High” risk scores. The MRS without ERST was compared to the MRS with ERST support for SOF mission planning and evaluated for significance.

Results: The combined MRS was drastically reduced with ERST involvement. The “time to ER” as well as “time to DCS” was evaluated and both found to be greatly reduced by the ERST. Actual time estimates were significantly reduced.

Discussion: Unconventional warfighting highlights the need for an organic and versatile medical team enabled for DCS near point-of-injury, evacuation and resuscitation to reduce operational risk.

Good Special Operations is Good Global Health: Translation of SOF Skills to Academic Skills
Eric Strand, 4th Year Medical Student, University of North Carolina School of Medicine

Global health efforts are undergoing an increased focus on ethics and sustainability. Rightful criticism of “medical tourism” and “savior complexes” in popular culture parallel global health academic discussions about what constitutes a worthwhile project and how power dynamics and culture play into the delivery of projects. In 2014, I spent eight weeks in Lilongwe, Malawi conducting clinical research at Kamuzu central hospital with UNC project Malawi. The project has a strong emphasis on capacity building, the methods of which closely mirror Special Operations missions. Many SOF skills are transferrable to conducting Global Health, whether in a research or in a clinical setting. Designing a study, writing an IRB and securing funding are often the most daunting steps for a new researcher. Any experienced SOF operator has participated and concept development for missions and training. The processes are very similar and should be recognized as a strength of former SOF personnel. Global health projects often fall short of initial expectations and will frequently experience setbacks and changing conditions. Host nation personnel may be overworked, underpaid, and unable to meet the demands of a project. Lab equipment may break down, changing the intended methods of a project. Managing these challenges is aligned perfectly with the qualities that SOF selects for and develops through training. In order to be ethically sound, a global health project must provide a benefit that persists. Special Operators will easily recognize methods for sustainable projects: partner with host nation workers, empower them, train them, and put their faces and names on the work. With the new focus on ethics and sustainability, academia is starting to learn what SOF has known all along, and SOF operators are well positioned to be leaders in the field.

Novel Low-Cost Aeromedical Evacuation on a C-12 Aircraft
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Motivation: Aeromedical Evacuation (AE) is a core capability of the US Air Force special operations and mobility missions. Aircraft outfitted for aeromedical evacuation require special configurations and crew training to airlift sick and wounded from the conflict. The C-12J, an efficient operational support aircraft

previously utilized in special operations personnel and cargo transport, has recently been outfitted to perform aeromedical evacuation. We describe here the process for developing the new mission of this aircraft.

Overview: The C-12J is based on the Beechcraft 1900C aircraft, a regional airliner already in use as an AE platform around the world. The C-12J's short field capability, small footprint, and all-weather-operation make it very well suited for austere airfield operations. The C-12J now operates as a routine AE asset, moving patients from Korea and Mainland Japan to Okinawa with two different patient configurations.

Significance: The C-12J is the newest AE platform in the Air Force inventory. It is also a model for future economical AE airlift operating out of not just large military bases, but also remote airfields. It currently operates with two approved configurations; a NATO litter ambulatory patient model, and a Spectrum Aerobed for higher acuity patient movements. These configurations allow the aircraft to carry both ambulatory and non-ambulatory patients while simultaneously moving cargo and/or passengers. The C-12J also participates in multi-lateral exercises, serving regional partners as an economical and unique training platform for small aircraft AE. The efforts to bring this mission to the C-12J and the aircraft's continued success at patient movement represent a model for other small aircraft AE mission development.

Point of Care (POC) Testing: A Comparison of Two Devices and the Impact of Expired Cartridges

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Background: Point of care (POC) testing is an essential component of far forward care. Prolonged field care requires accurate blood analysis across a range of environmental conditions and in extremes, use beyond the expiration date. We compared gold standard laboratory testing to two POC devices iSTAT (Abbott Laboratories, Abbott Park, IL) and EPOC, (Epocal Inc., Ottawa, Ontario, Canada) with and without expired cartridges.

Methods: The study was approved by UCMC and AFRL IRB's. Informed consent was obtained from subjects or their surrogate. At the time of standard of care (SOC) blood draws, additional blood was simultaneously analyzed using the POC devices. The EPOC devices were tested with current and expired cartridges (> 30 days past expiration date). Results are expressed as means ± SD and compared to POC devices using a t-test. Mean differences were calculated.

Results: Data from 100 subjects demonstrated that both POC devices were comparable to SOC.. Expired cartridges used in the EPOC did not result in a degradation in accuracy for ABG or electrolytes, except for pH and Base Deficit. Data below represent SOC/EPOC/EPOC expired cartridge/iSTAT for selected data. pH – 7.36 ±0.07/ 7.34 ± 0.06/ 7.29 ±0.07/ 7.33 ±0.06 Mean difference (-0.02±0.01/ -0.07±0.02/-0.03±0.01) PaO2 (mm Hg) – 81 ±16.8/ 77 ±21/ 77 ±21.3/ 79 ±22.7 Mean difference (-4.34±9.6/ -4.0±10.3/ -0.9±0.9) Hemoglobin (g/dl) – 9.0 ±1.3/ 9.7 ±3.2/ 9.8 ±3.2/ 9.9 ±2.9 Mean difference (0.64±3.1/ 0.72±3.15/ 0.83±2.8) Lactate (mmol) – 2.1 ± 1.2/ 2.2 ±1.2/ 2.2 ±1.2/ 2.0 ±1.2 Mean difference (0.15±0.2/ 0.14±0.3/ -0.04±0.03)

Conclusion: The EPOC device with expired cartridges, maintained clinical accuracy. The iSTAT device was clinically accurate. The values for pH and Base Excess/Deficit with the expired EPOC cartridges were clinically different. None of the differences in POC values would have resulted in a change in treatment.

Conflict and Disaster Medicine: The State of Battlefield Medicine in Ukraine

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Ukraine is at war with Russia and Russian militant proxies. Ukraine is still in transition to a stable modern state from that of a fragile one teetering on state failure. Owing to the difficulties associated with severing Soviet era state institutional ties with Russia, the birth of a modern Ukrainian State remains elusive and fragile. These events affect prolonged field care (PFC) and the application of TCCC .

We describe some of the institutional issues related to health and conclude that prevention is the best medicine and that state institutional capacity strengthening and resilience, accountability and transparency promote health most effectively. This is best accomplished by telling a story of ODC collaboration and coordination from tactical combat casualty care / tactical emergency casualty care (TCCC/TECC) to prolonged field care; where it has been and where it is headed. This brief study describes the human cost from 2014 - 2016 from conflict and offers some prescriptive policy considerations that may continue the state transition of Ukraine into a stable and sovereign nation by promoting health security through the Reforms Process.

In summary, Ukraine remains at hybrid war with Russia and this impacts mortality and morbidity of warfighting activity as outlined from 2014-2016. A highlight in the Reforms Process must remain NATO alignment with policy and principles and in addressing the PFC level of care and doctrinal change at the MoD Ukraine.

Far Forward Identification of Brain Dysfunction to Support Prolonged Field Care

Dr. Mark Tommerdahl, President and Founder, Cortical Metrics, LLC, Semora, NC; Gregory Rule, Project Manager, Applied Research Associates, Inc., San Antonio, TX; LTC (ret) James Reed, MSN, President, Sonas, Inc.

Cortical Metrics has developed a new system for assessing brain health that employs a portable computer peripheral to enable high resolution tests of within-brain connectivity. Mild traumatic brain injuries are difficult to diagnose or assess and are particularly difficult to assess in circumstances where triage decisions are necessary. The majority of methods currently proposed to solve this problem are either costly, non-portable, extremely slow, often invasive, and/or in many cases fail to definitively (and quantitatively) diagnose the condition or have the resolution to assess treatment efficacy. Direct measures of brain health are difficult to achieve because of both the cyto-architectural complexity of the brain and the resolution necessary to detect subtle changes in function even in optimal circumstances. The Brain Gauge delivers tactile (skin) stimulation to the fingertips, and leverages the neuroanatomical complexity that exists between the adjacent cortical areas that are activated by fingertip stimulation. The observed sensory percepts are highly influenced by interactions between adjacent brain areas and effectively provide a potentially high resolution metric of functional connectivity. The protocols that were both designed and validated from in vivo studies of cerebral cortical dynamics in non-human primates target a number of information processing mechanisms and are called cortical metrics. These have been demonstrated in multiple independent studies to be

sensitive to alterations in brain health. Viability of the method as an effective tool for tracking recovery from traumatic insult has been established in sports concussion studies (99% confidence level ($p<.01$) for differentiating individuals with and without concussion). Studies in military populations have been initiated. A major component of the current effort is the practical implementation of the method in the field, which includes delivery of easily interpretable results to SOF medics. A series of case studies, as well as formal research findings, will be presented.

Wireless Wearable Technology for the Management of In-Field Care

LTC Gregory Watson, MD, FACS, MC, USAR, Assistant Professor of Surgery & Critical Care, University of Pittsburgh; Brian Stancil, President, Stancil Technologies LLC; Dr. Philip LeDuc, William J. Brown Professor, Carnegie Mellon University Departments of Mechanical Engineering, Biomedical Engineering, Computational Biology, and Biological Sciences, Founding Director, Center for the Mechanics and Engineering of Cellular Systems; Dr. Carmel Majidi, Associate Professor, Mechanical Engineering Carnegie Mellon University, Courtesy Appointments, Robotics Institute, Civil and Environmental Engineering, Biomedical Engineering, Founding Director, Soft Materials Laboratory; Dr. Alexi Charalambides, Post-doc, Mechanical Engineering, Carnegie Mellon University

Background: Over the last 10 years, commoditization within the commercial wearable and Internet of Things (IoT) markets has rapidly improved the availability and capability of physiological monitoring sensors, microprocessors and low power wireless technology. These rapidly maturing fields will have a tremendous impact on battlefield care by allowing for remote monitoring, logging and processing of physiological data. However, challenges to adoption remain within complex tactical environments including size/weight/power limitations, reliability of the measured output and data security.

Methods: Recent advances in soft-matter engineering have led to the development of flexible and breathable smart materials with integrated electronics that can be unobtrusively placed in multiple locations on the body and can be made inexpensive enough that they can be discarded after a single use if necessary. An initial prototype of a wearable soft-matter bio-patch was developed, integrating reflective pulse oximetry, heartrate, temperature, and motion sensors with a wireless microprocessor capable of all-day data logging. The sensor uses operational profiles to manage power consumption while selectively logging and transmitting data depending on the scenario.

Results: Our prototype sensor was characterized in terms of size, weight, and power consumption as well as data resolution, throughput and logging capability. A roadmap for integration with existing military systems and standards will be discussed.

Discussion: The development of a disposal wireless wearable sensor will enable new methods of interaction between the warfighter, combat medics, and medical professionals leading to an improved ability to predict necessary life-saving interventions by rapidly detecting deteriorating conditions. Future generation devices will analyze physiological data and provide assistive recommendations relating to medical care, allowing medical professionals to more efficiently and effectively treat multiple simultaneous casualties.

R&D Efforts to Create a Surgical Fasciotomy Simulation for Training Special Ops Medical Personnel

William Pike, S&T Manager, Army Research Laboratory Advanced Training and Simulation Division; Jack Norfleet, Chief Engineer, Army Research Laboratory Advanced Training and Simulation Division; Richard Kelly, Instructor, Joint Special Operations Medical Training Center; Angela Alban, CEO, SiMETRI Inc.

The Army Research Laboratory – Human Research and Development Directorate – Advanced Training and Simulation Division (ARL-HRED-ATSD) and the Joint Special Operations Medical Training Center (JSOMTC) are developing a simulation capability to more effectively teach the two cut, four compartment fasciotomy procedure used by Special Operation Medics to treat lower leg compartment syndrome. This paper will discuss the research areas of: anatomical accuracy, procedural accuracy, tissue properties, and operational tempo. As a surgical simulation, anatomical and procedural accuracy were critical in achieving the learning goals. Tissue properties taken from literature and augmented with data from ATSD tissue research ensured that the materials were as realistic as possible. Operational tempo defined by student throughput, number of procedures per class, and times to reset the simulation rose in importance as current commercially available fasciotomy simulations do not adequately support the JSOMTC training mission. The paper will also illustrate how each of these areas were addressed using user-centric design and on critical task analysis based on the curriculum. Design tradeoffs will be discussed to explain the decision making process and how each research area affected the design. Finally, the paper will discuss the advantages and disadvantages of working with a DoD laboratory instead of industry.

The National Museum of Health and Medicine as a Unique Military Medical Resource

David Shackelford, Staff Curator, Alan Hawk, Historical Collections Manager, Tim Clarke, Jr., Deputy Director (Communications) and Adrianne Noe, Director, National Museum of Health and Medicine, Silver Spring, MD. The NMHM is an element of Research and Development, Defense Health Agency, Falls Church, VA

The National Museum of Health and Medicine (NMHM) is a multi-service Department of Defense museum aligned within Research and Development (J-9) at the Defense Health Agency. The NMHM was established during the Civil War as the Army Medical Museum as a center for the collection of specimens for research in military medicine and surgery. In 1862, Surgeon General William Hammond directed medical officers in the field to collect "specimens of morbid anatomy together with projectiles and foreign bodies removed" and to forward them to the newly founded museum for study. The museum has been assembling, presenting, and arranging for scientific inquiry such materials ever since. The collection now numbers more than 24 million items and offers visitors a unique perspective on military medicine, because it is one of the few places where the public can actually see the effects of traumatic injury and disease on the human body.

Historical Collections comprise a major collecting and research initiative consisting of artifacts that demonstrate both common practices and exceptional advances over time. Such instruments and devices are used in exhibitions here and, behind the scenes, by military and civilian researchers who are interested in evolutionary and revolutionary approaches to trauma care and in other investigations. NMHM assets support studies of structural and functional change, material choice, application methods, and research, development, and application models for these items. Exhibitions explore innovation in military medicine and rely upon the appropriately cleared work of special communities to foster continuing medical advances.

This poster or platform presents the mission and capabilities of the institution, offers examples of how collections have fostered advances in military medicine, describes public programming that encourages consideration of those advances and invites participation by the Special Operations/Medicine community. It will also be heavily illustrated with collections items.

Sleep Recovery and Habituation Heart Rate Variability Measured Recovery and Readiness to Train

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Introduction: Heart rate variability (HRV) has been shown to reflect physiologic changes due to various external stimuli. Our hypothesis is that benefits of realistic training can be quantitatively measured with HRV combined with salivary biometrics (SB) and thus provide an objective and repeatable measure of training.

Methods: We used a TV/Movie studio with realistic sets, props, and mass casualty special effects. A student cohort was used to derive training effectiveness measured by sleep recovery and stress versus training habituation. Training consisted of a full immersion medical intensive skills week targeted at second year medical students performed in the movie production studios of Stu Segall Productions. 50 hyper-realistic scenarios, simulation began at the point of injury, en route, ending with transition of care from surgery. The trainees staffed an ER, two OR's, triaged multiple victims, and performed real surgical procedures utilizing the Surgical CUTSUIT on live "patients". Saliva was collected before + after intense immersive scenarios. Continuous 1/1000 of a second HRV was recorded for analysis of immediate stress, habituation and sleep quality.

Results: Stress data of HRV combined with salivary amylase showed a strong correlation between stress and habituation. Stress Level/sAA correlated with habituation to stress at day 1 (r=0.91); day 2 (r=0.98); and day 3 (r=0.85). 10 of 12 students had significant sleep improvement during the week regardless of the intensity of the stress as measured by elevated cortisol levels from day 1 to 4. Habituation rates also increased as measured by amylase and were directly correlated with HRV values and sleep recovery rates. (r=0.916).

Conclusions: Training intensity was not associated with sleep conditions during training. Sleep improvement was directly associated with training habituation with HRV and SB thus providing an objective measure of training effectiveness.

Developing a System for SOF Medics to Predict Likely Interventions in an Emergency

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Background: Tactical combat casualty care (TCCC) presents significant challenges to medical personnel who are charged with assessing, monitoring, and caring for critically wounded soldiers. While technological advances have significantly reduced morbidity and mortality, current technologies do not enable continuous monitoring from the moment of injury until the patient has been transferred to higher level of care. This is particularly critical for special operations forces (SOF) medics, who are required to provide advanced care, often in austere conditions.

Method: This study involves developing a comprehensive solution to these problems. The system, SMARTriage is a wearable device that monitors vital signs. Data is transferred to medics' handheld devices, where TCCC algorithms are applied to provide treatment decision support. Medical recordkeeping is integrated into the system to provide a natural flow to the SOF medics' routines. The

system is also being designed to interface with the SOF Information Enterprise, so the information can be transferred on tactical networks. SMARTriage is currently being tested on simulated patient data. A clinical pilot study will be performed on Tampa Fire Rescue volunteers in 2017. Based on the results of the study, the system will be tailored for the specific needs of SOF medics.

Discussion: These next-generation medical devices will provide uninterrupted monitoring of vital signs, and will facilitate enhanced life-saving measures exactly when they are needed most. Given the significant loss of life that has been historically associated with TCCC, such technology could provide benefits to first responders and their patients in hostile environments. The long-term implications of the SMARTriage system is expected to advance the methods used to monitor and save lives, both on and off the battlefield.

Novel Approach to the Sterilization of Surgical Instruments in an Austere Environment Using Nonstandard Supplies

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BACKGROUND: Sterilization of surgical equipment in an austere environment is a challenge for the medical provider with limited medical equipment. In a situation where standard medical supplies are often limited the standard sterilization procedures are not used and instead clean procedures are utilized. In this study, we evaluate the use of nonstandard packaging to maximize sterility of equipment for those medical practitioners in an austere/wilderness setting.

OBJECTIVE: The purpose of this study was to evaluate the effectiveness of steam sterilization using nonstandard packaging to achieve sterility of surgical instruments.

METHODS: This is a pilot study to assess the usefulness of the above technique before austere clinical implementation. In nineteen samples, we used nonstandard packaging and used steam sterilization to verify the acceptable use.

RESULTS: The use of nonstandard packaging tested in multiple variations and combinations were all sterilized according to the steam chemical integrator and verified by the use of simple bio indicator devices.

CONCLUSIONS: The use of nonstandard packaging for the sterilization of surgical instruments may be a useful tool for the sterility process in the austere environment. However, further study is needed to validate these findings in the austere environment utilizing a pressure cooker to ensure steam sterilization effectiveness.

Invasive Reduction of Paraphimosis in an Adolescent Male While in a Deployed Austere Environment

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INTRODUCTION/OBJECTIVE: Paraphimosis is a urologic emergency with serious consequences including tissue necrosis and partial amputation if normal anatomy is not restored promptly. Invasive reduction of a paraphimosis requires minimal instruments and can be accomplished by experienced providers.

CASE PRESENTATION: This case describes a 10-year-old local African national with a paraphimosis for 10 days prior to initial evaluation that ultimately required invasive reduction while in a deployed austere environment. Manual reduction was attempted for 30 minutes and was unsuccessful due to the amount of edema present. A dorsal slit was made into the fibrotic prepuce ring and multiple needle punctures into the edematous tissue was performed. After this invasive procedure, the paraphimosis was successfully reduced manually. The patient then subsequently underwent an elective circumcision the following day.

DISCUSSION: Paraphimosis occurs when the foreskin becomes stuck in the retracted position, and eventually results in increased edema, ischemia, necrosis, and amputation of the glans if no corrective actions are taken. The most common cause is a pre-existing phimosis, or fibrosis of the prepuce ring. There are multiple reduction techniques discussed in the literature. A manual reduction should be attempted prior to more invasive techniques. If this fails, more invasive techniques include a dorsal slit to disrupt the fibrous prepuce ring, and a needling technique to decompress the edema. Alternative methods discussed in the literature include 1.) using a concentrated sugar applied to the glans in order to osmotically displace the edema, 2.) a hyaluronidase injection into the prepuce, and 3). soaking the penis in a surgical glove full of ice to reduce edema prior to attempting manual reduction.

CONCLUSION: This case brings to light the importance of having a familiarity with the various techniques of reducing a paraphimosis since it is a urologic emergency that can easily be corrected in a deployed setting.

Closed Loop Control Technology: Enhancing Combat Casualty Care in Austere Environments

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BACKGROUND: Every combat contingency that suffers casualties mandates skillful application of mechanical ventilation/oxygenation to meet patient demands. Establishing technology to improve safety/efficacy of critical care interventions would likely prove beneficial to the entire medical system. Closed loop control (CLC) of oxygenation has proven successful in trials, and should be considered for military medical operations.

METHODS: Trauma/Surgical ICU patients, ages of 18-65, requiring mechanical ventilation were selected as a surrogate population to combat casualties. All were enrolled per randomized, cross-over trial of CLC of FIO2 compared to manual control. The ventilator and computer system permitted automatic adjustment of FIO2 in response to pulse oximetry. Safety/efficacy criteria were evaluated based on prevention of hypoxemia (SpO2 ≤ 88%), ability of the controller to maintain oxygen saturation within targeted range of 92-96%, and oxygen consumption.

RESULTS: Enrollment of 95 subjects yielded an average age of 35 and mean Injury Severity Score of 34□13. The mean duration of hypoxemia in the CLC group was less than half experienced by the control population. Amount of time in the target range was 189.95 mins in the closed loop group compared to 74.52 mins in control group, with a 34% savings in oxygen volume. Hyperoxia (97-100% SpO2) was reduced by almost 300%.

DISCUSSION: Evidence supports the utility of CLC to mitigate the incidence of hypo/hyperoxemia/reduce oxygen consumption. An episode of hypoxemia in closed head injury has been associated with worsening outcomes, while reducing hyperoxia reduces unintended consequences. We propose a multi-center trial to assess CLC for military application. Subsequent studies would combine oxygen/PEEP/ventilation control to establish capacity of CLC systems. Previous efforts have identified the utility/efficacy of mechanical ventilator control/.delivery of oxygen produced from an oxygen concentrator, in interoperable system. These efficiencies could reduce reliance on compressed gas systems, minimize logistics, and afford austere environments resources previously inaccessible/limited.

High Altitude Ground Operations

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HIGH-ALTITUDE GROUND OPERATIONS PROBLEM STATEMENT: Military ground operations by some units occur at high elevations such as found in some parts of Afghanistan. Preventing and/or treating altitude illnesses is a required skill in these settings. Lack of this knowledge can cause mission failure. This topic is pertinent to the medical professionals who oversee personnel engaged in high-altitude ground operations.

TOPIC: This session will cover etiologic factors in altitude illnesses such as acute mountain sickness, high-altitude pulmonary edema, and high-altitude cerebral edema; the prophylaxis and treatment of these altitude illnesses; and the use of pressure gear such as Gamov bags in these settings.

APPLICATIONS: Knowledge gained in high-altitude mountain medicine has immediate impact on improving safety and enhancing mission success during high-altitude ground operations and is also useful to units of all U.S. military branches as well as to all international military and civilian organizations that conduct ground operations at high altitude including combat operations as well as search and rescue.

A Case of Emergent Fasciotomy Caused by Workout Supplements in a Special Operations Candidate

Dr. Jacob Shook, PGY-1, CRDAMC, Family Medicine Residency; Dr. Jocelyn Hu, PGY-3 Chief Resident, Family Medicine Residency

Introduction: Dietary supplements (DS) are commonly used in the workout community. These unregulated products promise to enhance performance with increased endurance, recovery, and increased drive. DS are used by many service members who are looking to improve their PT scores, get stronger, or be a better soldier. Some are using a pre-workout (PREW), post-workout (POSTW), and recovery supplements (RS).

Case Presentation: A previously healthy, physically fit 30 year old male soldier presented with weakness, dizziness, nausea, vomiting and syncopal episode after running 4 miles. He is an active individual who participates in strenuous activity regularly. He was training for a Special Forces (SF) assessment; during his training he started taking 3 new DS to augment his physical abilities. His new supplements were Arnold Schwarzenegger Iron Pack, Arnold Schwarzenegger Iron pump, and Chem-Tek-Labs Ligandrol added to his old DS of CN6, Gorilla Alpha Gen. On presentation to he had a rectal

temperature of 104° F, heart rate of 167. He was evaluated and found to have rhabdomyolysis, heat stroke, acute kidney injury, and compartment syndrome. His compartment syndrome in his bilateral lower extremities required emergent fasciotomies bilaterally. He was also found to have acute myocardial injury with raising cardiac troponin form 0.04 to 0.28 in one hour. He had prolonged recovery which was complicated due to severity of injuries with residual neuromotor deficits that ended up requiring a MEB for foot drop.

Discussion/Conclusion: A significant contributing factor the severity of his injuries was the use of DS. DS are used by up to 60-70% of active duty military [2][10] with higher prevalence in elite groups [1]. Most of these supplements have some negative impact on the health of soldiers affecting the overall readiness of the force. It can affect retention of an otherwise outstanding individual. The effects of the substances often compound when stacked causing higher risks of adverse events such as acute kidney injury, acute liver injury, arrhythmias, paresthesias, mood swings, seizures, syncope, and death. This patient required emergent b/l fasciotomy which has severe risks in austere environment. His other injuries compounded treatment complications, and this service member found to no longer be fit for

Development and Testing of a Novel Chest Decompression Template

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Background: Decompression of tension pneumothorax is a lifesaving procedure. Yet clinical experience and the literature suggest that pre-hospital and in-hospital providers have difficulty identifying the procedural sites for both anterior and lateral decompression approaches. “Cardiac box”, large vessel and abdominal solid organ injury may result from incorrect needle or chest tube placement.

Methods: Physicians and engineers worked together to develop a universal template for simplified identification of the 4th or 5th intercostal space (ICS) on the anterior axillary line (AAL) based on anthropometric data previously gathered on >1000 military personnel. Thirteen combat medics and civilian paramedics were then asked to identify the 4th or 5th ICS along the AAL on a single live, male subject – initially without guidance and then with the template after only 60 seconds of template training.

Results: Without the template, 1 of 13 medics correctly identified the lateral site. With the template, 10 of 13 correctly identified the site – a 10x improvement. Medic feedback led to design enhancements that will enable the template to more accurately guide decompression at the lateral site. A next generation template has been designed that also incorporates a universal, site-finding feature for the anterior (2nd ICS, mid-clavicular line) decompression site. Results of follow-up testing incorporating (1) a larger number of volunteers to reflect a range of body types and (2) both lateral and anterior approaches will be presented. Lessons learned regarding usability of the single template device will also be shared.

Discussion: A simple, unpowered, lightweight, inexpensive chest decompression template may increase the accuracy and success of chest decompression performed in the field and in-hospital, and prevent

further injury to the patient. The device may also serve a training function and help guard against attrition of procedural knowledge and skill.

Evaluation of XStat and Combat Gauze in a Swine Model of Junctional Hemorrhage with Coagulopathy
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Background: Hemorrhage is associated with the majority of potentially survivable deaths on the battlefield. Effective and field tested products are lacking to treat junctional and noncompressible injuries. XStat is a newly developed, FDA-approved product designed to treat junctional hemorrhage. The product is composed of minisponges that expand on contact with blood to produce tamponade. The committee on tactical combat casualty care has recently approved the product as part of its guidelines, but data is lacking to assess its efficacy in different injury types or physiologic states.
Methods: Large (70-90kg) male swine were used in all experiments. Following splenectomy, coagulopathy was induced by replacing 60% of the animal's estimated blood volume with room temperature Hextend. Uncontrolled hemorrhage was initiated by transection of both axillary artery and vein following dissection and lidocaine incubation. Free bleed was allowed to proceed for 30 seconds until intervention with either XStat or Combat Gauze and standard backing. Primary outcomes were survival, hemostasis, and blood loss.
Results: Nineteen, healthy animals were entered into the study. XStat-treated animals achieved hemostasis in less time and remained hemostatic longer than Combat Gauze. Significantly less blood was lost during the first 10 minutes following injury in the XStat group than the Combat Gauze group. However, no differences were observed between XStat-treated and Combat Gauze-treated groups based on survival. All animals died before the end of the observation period except one in the XStat-treated group.
Discussion: The results presented here show XStat performed better than Combat Gauze in this model of junctional hemorrhage in coagulopathic animals. Continued testing and evaluation of XStat should be performed to optimize application and to determine appropriate wounding patterns.

A Multi-Level Mixed Methods Approach to Study the Effectiveness of a Primary Care Progressive Return to Activity Protocol After Acute Mild Traumatic Brain Injury/Concussion in the Military
Jason M. Bailie, PhD, Senior Clinical Research Director, Neuropsychologist, Defense and Veterans Brain Injury Center (DVBIC), CTR, General Dynamics Health Solutions

The large number of U.S. service members diagnosed with concussion/mild traumatic brain injury each year underscores the necessity for clear and effective clinical guidance for managing concussion in both deployed and non-deployed settings. Relevant research continues to emerge supporting a gradual return to pre-injury activity levels without aggravating symptoms; however, available guidance does not provide detailed standards for this return to activity process. To fill this gap, the Defense and Veterans Brain Injury Center released a recommendation for primary care providers detailing a step-wise return to unrestricted activity following acute concussion. This guidance was developed in collaboration with an interdisciplinary group of clinical, military, and academic subject matter experts using an evidence-based approach. Here we describe a multi-level, mixed-methods approach to evaluate the recommendation, incorporating outcomes from both patients and providers, to ensure positive patient outcomes, to discover barriers to implementation by providers, and to identify ways to improve the recommendation. Procedures were developed to implement the study within complex but ecologically-valid settings at multiple military treatment facilities and operational medical units. Special consideration was given to expected challenges such as frequent movement of military personnel,

selection of appropriate design and measures, study implementation at multiple sites, and involvement of multiple service branches (Army, Navy, and Marine Corps). To date, all providers (N = 35) and 72 of the targeted 200 patients have been enrolled. Baseline findings from providers highlight barriers and facilitators to best practice for military acute concussion. Preliminary findings are consistent with previous research demonstrating that published educational material does not automatically translate into compliance by medical providers and needs to be supplemented by face-to-face educational interventions. We conclude by highlighting lessons learned from this alternative methodology study which will provide useful information on patient outcomes as result of the clinical guidance that is received.

Developing a Prolonged Field Care Human Performance Training and Testing Platform

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Introduction: Military medical providers at all levels may experience discordance between their garrison medical practice and the medical care they provide while deployed to operational settings. Consequently, clinicians may have limited experience in combat casualty care, particularly of complex, critically ill casualties in resource-limited environments. The military provides extensive training for medical providers, but training – usually a combination of didactics and simulation – may not help clinicians when nuanced care requires judgment gained through experience. This is especially true when pre-hospital providers –contextually advanced practice medics in the special operations forces (SOF) – must provide prolonged field care (PFC) of critically ill/injured casualties.

Methods: We intend to develop a methodology that tests human performance during PFC and to investigate how new technology solutions, particularly telemedicine, impacts performance. This testing platform should allow the testing of various technology solutions and determine if they improve human performance before fielding. Demonstrating the value of new technology to enhance human performance and piloting its use in simulated conditions increases the likelihood that it will be accepted by users and avoid the potential of doing harm.

Results: We will establish a standardized training program that addresses key critical care skills that all subjects experience before testing. Subjects will then record their daily medical care in their garrison work environment. Subjects will be randomized to PFC simulation scenarios with/without telemedicine consultation. Both groups will have access to internet-based information and paper references typical of a deployed environment. We will measure subject performance including efficiency, accuracy, and reliability of medical decisions as well as cognitive work measured by validated surveys and physiologic measurements. Subjective experiences will be measured by custom surveys and interviews.

Discussion: This methodology will better identify useful and clinically beneficial technology that will improve combat casualty care more effectively than methods currently in use.

Belts Evaluated as Limb Tourniquets: BELT Study Comparing Trouser Supporters Used as Medical Devices in a Manikin Model of Wound Bleeding

Blake Bequette, BS; John F. Kragh Jr, MD; James K. Aden III, PhD; Michael A. Dubick, PhD

Background: The purpose of the present study is to compare performance of models of belt tourniquet in hemorrhage control.

Methods: Belts evaluated as limb tourniquets were studied (BELT study) as test articles in an experiment designed to test effectiveness of pants belts not as clothing support but as nonimprovised medical devices in control of bleeding from a manikin. Models included Tourni-belt, Tourniquet Belt, ParaBelt, and Battle Buddy. Data included effectiveness, time to stop bleeding, total time of application, pressure, blood loss, and composite results (score count of good results; composite outcome good if every component was good).

Results: Differences among effectiveness percentages by model of belt tourniquet were not statistically significant. The difference in means between users was statistically significant for stop time, total time, pressure, blood loss, composite score, and composite outcome. Mean time to stop bleeding differed for only one pair of models after the Tukey-Kramer adjustment; ParaBelt was faster than Tourniquet Belt. Mean total time of application differed between ParaBelt–Tourniquet Belt and Tourni-belt–Tourniquet Belt; the former model in both pairs was faster. No significant difference in mean blood loss by model was found. For composite outcome score, no pairwise difference between models was significant. For composite outcome (good-bad), ParaBelt had 75% of tests with good results; the other three models had significantly worse results.

Conclusion: In a preliminary laboratory analysis of belt tourniquet models using a manikin, performance differed by model. ParaBelt had 75% of tests with good results which was better than other models.

Leveraging Advances in SOF Human Performance and Wearable and Wireless Technologies to Amplify Training Effectiveness and Provide Peak Mission Readiness

Col. Dan McCarron (USMC, ret.), Vice President, Operations, tiag® (The Informatics Applications Group, Inc.)

Background: Like professional athletes, Special Operations Forces (SOF) require managed high-end training to balance increased performance with reduced risk of injuries and ensure optimized readiness outcomes. CoachMePlus (CM+) is a web-based performance application employed by more than 200 professional and collegiate sports teams for tracking elite athlete performance. Leveraging wireless and wearable technologies, it uncovers performance trends and highlights risk factors. Each program is individualized to the team and the player to ensure optimal game-day readiness. The Warrior Performance Platform (WP2) is leveraging CoachMePlus (CM+) software and advances in SOF Human Performance and Sports research. WP2 will deliver end-to-end solutions that amplify training effectiveness and improve overall SOF readiness.

Methods: The similarities between elite athletes and SOF warriors have been evaluated to understand common training processes and factors associated with increased risk from exhaustion and injury. Utilizing these initial insights, CM+ has been transformed into WP2. Leveraging real world insights gained during a 6-month pilot, WP2 will be further modified to maximize its ability to significantly improve the physical conditioning, readiness and resilience of SOF.

Results: WP2 leverages proven technologies and multiple case studies to ensure maximum SOF readiness. Its programming accommodates diverse SOF mission requirements and uses mobile applications to deliver individual and command readiness dashboards that provide critical insights to key decision makers throughout the entire mission readiness cycle.

Discussion: When fully developed following the six-month pilot, WP2 will provide SOF leadership a currently unavailable capability. It will immediately identify individual performance issues across an entire command, permitting concurrent real-time adjustments to multiple training plans to ensure every individual simultaneously achieves peak mission readiness. At the conclusion of the pilot, we will present an evaluation of lessons learned and the overall benefits of WP2. Preliminary results will be available for presentation at the May SOMA conference.

The "Shrail" System: A Direct Comparison to the Current DoD Deployment Operating Table

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Background: Forward Surgical Teams (FST's) have been widely used to provide emergency resuscitative surgical care during high intensity offensive operations. There continues to be an operational need for FST's to function in austere locations with the utmost flexibility as the doctrine of prolonged field care (PFC) is implemented. However, the current surgical equipment used is burdensome and hinders movement flexibility essential for PFC. In addition, it lacks a uniform system of incorporating standard operating room/surgical equipment into the current FST. The "Shrail" system is a lightweight, rail system that outfits the NATO litter with the same side rail system used on permanent operating room beds, thus creating a surgical table with full surgical exposure and operative capabilities. We sought to compare the current FST operating table, the English Table, to the "Shrail" system.

Methods: A local FST was utilized to compare the English Table (ET) to the "Shrail". Twenty construction time trials were performed. After construction, the device specifics and capabilities of the English Table and the "Shrail" were also compared.
Results: The time required to construct the "Shrail" was significantly less than the time required for the ET ($p<.0001$). The mean time for the "Shrail" was 80.75 seconds compared to 151.60 seconds. The "Shrail" weighs less (15lbs vs. 161lbs), has a smaller footprint (.66 ft3 vs. 11.4 ft3), and is more equipped for PFC (operative exposure, patient positioning, secure transport, ventilatory/anesthesia management, and extremity immobilization).

Discussion: The current FST operating table is heavy, burdensome, and timely to set up. It also lacks a simple system of incorporating necessary operating equipment. The "Shrail" offers more surgical capabilities than the current configuration without the added time, weight, or space. It is better suited for the demands of an FST and during prolonged field care.

Field Based High Sensitivity Rapid Detection of Pathogenic Viruses in Urine

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BACKGROUND: The emerging Zika virus threat and our ability to detect and subsequently contain its spread are of great military relevance. We present the development of a rapid, simple test for detecting

Zika as well as other clinically relevant arboviruses (Dengue, West Nile, Chikungunya, and Yellow Fever) that can be rapidly and easily implemented in the field. This method allows for real-time identification of infected individuals through a single voided urine sample that can be collected and analyzed in austere environments using a compact, light, self-contained, and non-battery operated test.

METHODS: We have developed a prototype kit that allows rapid detection using highly specific primers with demonstrated specificity for Zika, Dengue, Chikungunya, West Nile, and Yellow Fever viruses. This method utilizes a patient's urine and can be completed within 30 minutes.

RESULTS: For initial proof-of-principle, we have focused on Zika and Dengue virus detection. We have pilot data demonstrating that we can detect Zika and Dengue in urine in under 20 minutes. We have also developed an internal control to validate that the sample was processed and that the test was performed correctly.

DISCUSSION: We have developed a prototype test that allows rapid, highly sensitive and specific diagnostic monitoring of military personnel using only urine. Enhanced surveillance using this technology will allow SOF to assess the impact of arboviruses on current service members stationed globally in at-risk areas. Furthermore, the creation of a point of care, field based reliable testing kit will provide real-time actionable medical intelligence to military leaders and enhance their ability to identify pertinent outbreaks and risks for future deployments. Most critically, development of these technologies could be rapidly applied to new pathogens and mosquito borne diseases in the future.

The Impact of Sleep Deprivation in Military Surgical Teams: A Systematic Review

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Background: Fatigue in military operations leads to safety and operational problems due to a decrease in alertness and performance. The primary method of counteracting the effects of sleep deprivation is to increase nightly sleep time, which in operational situations is not always feasible. History has taught us that surgeons and surgical teams are finite resources that cannot operate on patients indefinitely.

Methods: A systematic review was conducted using the search terms 'sleep' and 'deprivation' examining the impact of sleep deprivation on cognitive performance in military surgical teams. Studies examining outcomes on intensive care patients and subjects with comorbidities were not addressed in this review.

Results: Sleep deprivation in any 'out-of-hours' surgery has a significant impact on overall morbidity and mortality. Sleep deprivation in surgeons and surgical trainees negatively impacts cognitive performance and puts their own and patients' health at risk. All published research lacks consensus when defining 'sleep deprivation' and 'rested' states. It is recognised that it would be unethical to conduct a well-designed randomised controlled trial, to determine the effects of fatigue on performance in surgery; however, there is a paucity between surrogate markers and applying simulated results to actual clinical performance. This requires further research. Recommended methods of combating fatigue include: prophylactically 'sleep-banking' prior to known periods of sleep deprivation, napping, use of stimulant or alert- ing substances such as modafinil, coordinated work schedules to reduce circadian desynchronisation and regular breaks with enforced rest periods.

Conclusions: A forward surgical team will become combat-ineffective after 48 hours of continuous operations. This systematic review recommends implementing on-call periods of no more than 12 hours in duration, with adequate rest periods every 24 hours. Drug therapies and sleep banking may, in the short term, prevent negative effects of acute sleep deprivation.

A Novel Perfused Cadaver Model for Resuscitative Endovascular Balloon Occlusion of the Aorta (REBOA)

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Background: Uncontrolled hemorrhage still accounts for as much as 25% of death on the battlefield. Resuscitative endovascular balloon occlusion of the aorta (REBOA) has been posed as an alternative to resuscitative thoracotomy for non-compressible hemorrhage control. Recent analysis of combat casualties in OEF has suggested that 18.5% of those dying from exsanguinating hemorrhage may be temporarily controlled with the use of REBOA. Percutaneous endovascular procedures such as this have been limited to acute care surgeons, interventionalists and vascular surgeons. With the advent of new technology and the ability to place REBOA catheters through smaller endovascular sheaths, the procedure can now be performed by emergency medicine providers. Adequate training and simulation models are still in development for the use of the procedure.
Objective: Create the ideal prehospital training simulator for REBOA catheter placement. The goals of design were to create a simple, easily reproducible, and realistic model to simulate placing REBOA in field/austere conditions.

Design/Methods: We conducted a systematic review of the published literature on REBOA, conducted virtual reality simulator training, performed interviews with subject matter experts and visited the labs at the Centre for Health Sciences in Bulverde, TX, the Fresh Tissue Dissection Laboratory at Los Angeles County and USC Keck School of Medicine, CA.

Results: We developed what we believe is the ideal simulation model for REBOA catheter placement using a perfused human cadaver model. Our model includes many elements from previously published models of perfused cadaver simulation as well as the unique aspects of placing extremity tourniquets and perfusing the venous side using a femoral intraosseus (IO) line.

Conclusion: This model has been used in the lab setting with good results.
Impact: The model described can be used in the field setting with minimal resources and accurately simulates the critical skills for REBOA catheter placement.

Fluid Resuscitation In Major Burns: Is There A Better Way?

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Eighty years after Frank Underhill's brilliant observation on the importance of fluid therapy on patient survival after major burns, clinicians continue to struggle to find that perfect formula predicting intravenous fluid requirements (Underhill, 1930). Early fluid resuscitation is still the key factor in the early management of major burns. Debate, research, and controversy continue today regarding the

best methods to determine appropriate fluid volume administration to prevent hypovolemic shock, while avoiding fluid over-resuscitation (Baxter, 1974; Pruitt, 2000). The Parkland formula has been in use for fluid therapy in burns for over 40 years. However, in the last decade evidence suggests that the Parkland formula does not predict resuscitative fluid volume requirements as well as once thought, specifically in patients with a larger burn surface area. Indeed, it appears that this patient population receives more fluid per percent of TBSA burned than in the past (Pruitt, 2000). Pruitt has coined a phrase that describes this over-resuscitation phenomenon as "fluid creep" (Pruitt, 2000, p. 568). Fluid therapy in severely burned patients plays a fundamental role in the cascade of physiological processes that occur during the early period following injury. The potential consequences of under-resuscitation include hypovolemic shock, inadequate tissue perfusion, and renal failure (Cancio et al., 2004). However, at the same time, there has been an increase in awareness among burn experts about the potentially deleterious effects of massive volumes of fluids administered in the initial stages of burn shock resuscitation. These deleterious effects include: 1) orbital, abdominal, and extremity compartment syndromes; 2) acute respiratory distress syndrome (ARDS); 3) prolonged ventilator dependence and ICU stay; 4) and increased mortality (Azzopardi, McWilliams, Iyer, & Whitaker, 2009). This will be a systematic review of literature and a retrospective review of charts project with a goal of changing clinical practice at one institution.

Triumph Over Tragedy, Roll Out of Trauma Care to the Shreveport Police Department

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Tactical trauma care has slowly evolved within law enforcement agencies, driven by advances in military medicine. On August 5th, 2015 an event transpired that would not only change basic training, but also the entire focus of the Shreveport Police Department's (SPD) approach to trauma care. While responding to a domestic violence call, Officer Thomas LaValley was ambushed and shot multiple times, transported to the nearby trauma center where he later died. While this unfortunate incident has become all too common in today's society, it served as a watershed moment for SPD.
In response to his death, several officers from the patrol division collaborated to ensure a positive outcome from this tragedy. Financial support for the project was obtained from the community to purchase enough kits to supply the entire department. The Caddo Parish Sheriff's Office Tactical Medical Unit was recruited to develop and provide the curriculum, as well as hands on instruction for the course.

The resulting 2-hour course is based upon TECC guidelines. It was specifically designed to treat hemorrhage, the primary cause of traumatic death in the pre-hospital environment. Class is centered upon rapid transport, hemostatic gauze and a compression tourniquet. The class is primarily hands on and has achieved overwhelmingly positive response from attendees. The developed trauma courses and personal trauma kit is now part of the SPD academy curriculum, and mandatory for all SPD Officers.

This course has served not only to improve the care provided to injured law enforcement officers, but additionally has saved the lives of twelve civilians injured in traumatic incidents. Seven other area law enforcement agencies were trained as well.

This model serves as a positive example of a community coming together to overcome emotional, financial and political barriers to achieve the best care possible for it's law enforcement officers and citizens.