

A Sampling of TCCC and ERCCC Journal Watch Abstracts From 2021

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The Committee on Tactical Combat Casualty Care (CoTCCC) and the Committee on En Route Combat Casualty Care (CoERCCC) conduct a monthly screening and review of the published medical literature for relevance to the tactical, pre-hospital, and en route care guidelines and operational communities. Since 2008, the CoTCCC has published and distributed a quarterly journal watch and CoERCCC was added in 2020. We now publish a combined quarterly and annual journal watch on Deployed Medicine. This journal watch can be accessed at www.deployedmedicine.com or by downloading the Deployed Medicine mobile application to a phone or device.

The journal watch effort is a critical component to the TCCC and ERCCC clinical practice guidelines remaining evidence-based and up to date with current medical practice and application. Since their inception, the committees have updated their guidelines based on ongoing review of the published civilian and military prehospital trauma literature contrasted with interaction with military combat casualty care research institutions; Joint Trauma System case reports; input from service lessons learned centers; and direct input from experienced combat medical personnel.

Using a keyword search of 83 combination terms and the PubMed.gov search site, Danielle Davis conducts a monthly pull of medical literature abstracts. These abstracts are then reviewed and identified by the CoTCCC and CoERCCC staff for relevance to ongoing and potential committee efforts. The identified abstracts are then pulled as full articles for a more thorough review for applicability. Articles pertinent to ongoing change proposals are provided to the change leads for potential inclusion their work efforts. Those and remaining articles specifically related to TCCC and ERCCC topics are included in the combined quarterly journal watch.

The review and selection of articles for inclusion in the journal watch does not imply agreement or disagreement with the contents nor constitute a change in TCCC or ERCCC guidelines, practices, or training. Additionally, neither selection of individual articles or publications should be construed as an endorsement by the US Government, Department of Defense, or the Defense Health Agency.

On the Deployed Medicine site, links are provided to respective publications for further reading and research. Additional log-in requirements may be required at various medical literature or organizational sites. The Joint Trauma System and Deployed Medicine do not provide downloadable articles or free access to journal sites. Access may be acquired through service medical departments/commands or medical agencies/organizations or personal subscriptions.

In 2021, the CoTCCC and CoERCCC staff screened and reviewed 2,739 medical literature abstracts using the process described above. Ultimately, 357 articles were selected for detailed review and inclusion in the journal watch. The abstracts that follow are a sampling of 25 articles published between December 2020 and December 2021. The complete list is available on Deployed Medicine.

A Prehospital Scoring System for Predicting the Need for Emergent Blood Product Transfusion

Guy Avital, Shaul Gelikas, Irina Radomislensky, Avishai M. Tsur, Alex Sorkin, Eilat Shinar, Moran Bodas, Mark H. Yazer, Andrew P. Cap, Jacob Chen, Elon Glassberg, Avi Benov
Transfusion. 2021;61 Suppl 1:S195-S205.

Background: Several tools have been proven to predict the need for massive transfusion in trauma casualties, yet tools that are easily applicable in the prehospital setting for predicting the need for any blood product transfusion in the emergency department (ED) are lacking. **Methods:** A retrospective analysis of the cross-referenced Israeli Defense Forces Trauma Registry and the Israeli National Trauma Registry databases was performed to identify predictors for any blood product transfusion in the ED. A scoring system was developed after internally validating the prediction model. Division to risk groups was performed. **Results:** Seven variables (systolic blood pressure, heart rate, arterial oxygen saturation, trunk involvement, mechanism of injury, chest decompression, and tourniquet application) were included in the scoring system, ranging from 0 to 11.5. Risk groups for ED transfusion included very low (0.8%), low (3.2%), intermediate (8.5%), and high (31.2%) risk. **Conclusion:** A scoring system for predicting the need for any blood product transfusion in the ED was developed, based on information readily available in the early stages of prehospital resuscitation, allowing the receiving medical facility to prepare for that need.

The Impact of Prehospital TXA on Mortality Among Bleeding Trauma Patients: A Systematic Review and Meta-Analysis

Ateeq Almuwallad, Elaine Cole, Jennifer Ross, Zane Perkins, Ross Davenport
J Trauma Acute Care Surg. 2021;90(5):901-907.

Background: Tranexamic acid (TXA) is an antifibrinolytic drug associated with improved survival among trauma patients with hemorrhage. Tranexamic acid is considered a primary hemostatic intervention in prehospital for treatment of bleeding alongside blood product transfusion. **Methods:** A systematic review and meta-analysis was conducted to investigate the impact of prehospital TXA on mortality among trauma patients with bleeding. A systematic search was conducted using the National Institute for Health and Care Excellence Healthcare Databases Advanced Search library which contain the following of databases: EMBASE, Medline, PubMed, BNI, EMCARE, and HMIC. Other databases searched included SCOPUS and the Cochrane Central Register for Clinical Trials Library. Quality assessment tools were applied among included studies; Cochrane Risk of Bias for randomized control trials and Newcastle-Ottawa Scale for cohort observational studies. **Results:** A total of 797 publications were identified from the initial database search. After removing duplicates and

applying inclusion/exclusion criteria, four studies were included in the review and meta-analysis which identified a significant survival benefit in patients who received prehospital TXA versus no TXA. Three observational cohort and one randomized control trial were included into the review with a total of 2,347 patients (TXA, 1,169 vs. no TXA, 1,178). There was a significant reduction in 24 hours mortality; odds ratio (OR) of 0.60 (95% confidence interval [CI], 0.37–0.99). No statistical significant differences in 28 days to 30 days mortality; OR of 0.69 (95% CI, 0.47–1.02), or venous thromboembolism OR of 1.49 (95% CI, 0.90–2.46) were found. **Conclusion:** This review demonstrates that prehospital TXA is associated with significant reductions in the early (24-hour) mortality of trauma patients with suspected or confirmed hemorrhage but no increase in the incidence of venous thromboembolism.

High Success Rate of Prehospital and En Route Cricothyroidotomy Performed in the Israel Defense Forces: 20 Years of Experience

Eran Beit Ner, Avishai M. Tsur, Roy Nadler, Elon Glassberg, Avi Benov, Jacob Chen

Prehosp Disaster Med. 2021;36(6):713–718.

Introduction: Securing the airway is a crucial stage of trauma care. Cricothyroidotomy (CRIC) is often addressed as a salvage procedure in complicated cases or following a failed endotracheal intubation (ETI). Nevertheless, it is a very important skill in prehospital settings, such as on the battlefield. **Hypothesis/problem:** This study aimed to review the Israel Defense Forces (IDF) experience with CRIC over the past two decades. **Methods:** The IDF Trauma Registry (IDF-TR) holds data on all trauma casualties (civilian and military) cared for by military medical teams since 1997. Data of all casualties treated by IDF from 1998 through 2018 were extracted and analyzed to identify all patients who underwent CRIC procedures. Variables describing the incident scenario, patient's characteristics, injury pattern, treatment, and outcome were extracted. The success rate of the procedure was described, and selected variables were further analyzed and compared using the Fisher's-exact test to identify their effect on the success and failure rates. Odds Ratio (OR) was further calculated for the effect of different body part involvement on success and for the mortality after failed ETI. **Results:** One hundred fifty-three casualties on which a CRIC attempt was made were identified from the IDF-TR records. The overall success rate of CRIC was reported at 88%. In patients who underwent one or two attempts, the success rate was 86%. No difference was found across providers (physician versus paramedic). The CRIC success rates for casualties with and without head trauma were 80% and 92%, respectively ($P = 0.06$). Overall mortality was 33%. **Conclusion:** This study shows that CRIC is of merit in airway management as it has shown to have consistently high success rates throughout different levels of training, injuries, and previous attempts with ETI. Care providers should be encouraged to retain and develop this skill as part of their toolbox.

Prehospital Whole Blood Reduces Early Mortality in Patients With Hemorrhagic Shock

Maxwell A. Braverman, Alison Smith, Douglas Pokorny, Benjamin Axtman, Charles Patrick Shaban, Lauran Barry, Hannah Corral, Rachelle Babbitt Jonas, Michael Shiels, Randall Schaefer, Eric Epley, Christopher Winckler, Elizabeth Waltman, Brian J. Eastridge, Susannah E. Nicholson, Ronald M. Stewart, Donald H. Jenkins

Transfusion. 2021;61 Suppl 1:S15–S21.

Background: Low titer O+ whole blood (LTOWB) is being increasingly used for resuscitation of hemorrhagic shock in military and civilian settings. The objective of this study was to identify the impact of prehospital LTOWB on survival for patients in shock receiving prehospital LTOWB transfusion. **Study design and methods:** A single institutional trauma registry was queried for patients undergoing prehospital transfusion between 2015

and 2019. Patients were stratified based on prehospital LTOWB transfusion (PHT) or no prehospital transfusion (NT). Outcomes measured included emergency department (ED), 6-h and hospital mortality, change in shock index (SI), and incidence of massive transfusion. Statistical analyses were performed. **Results:** A total of 538 patients met inclusion criteria. Patients undergoing PHT had worse shock physiology (median SI 1.25 vs. 0.95, $p < 0.001$) with greater reversal of shock upon arrival (-0.28 vs. -0.002 , $p < 0.001$). In a propensity-matched group of 214 patients with prehospital shock, 58 patients underwent PHT and 156 did not. Demographics were similar between the groups. Mean improvement in SI between scene and ED was greatest for patients in the PHT group with a lower trauma bay mortality (0% vs. 7%, $p = 0.04$). No survival benefit for patients in prehospital cardiac arrest receiving LTOWB was found ($p > 0.05$). **Discussion:** This study demonstrated that trauma patients who received prehospital LTOWB transfusion had a greater improvement in SI and a reduction in early mortality. Patient with prehospital cardiac arrest did not have an improvement in survival. These findings support LTOWB use in the prehospital setting. Further multi-institutional prospective studies are needed.

Prehospital End-Tidal Carbon Dioxide Predicts Hemorrhagic Shock Upon Emergency Department Arrival

Natalie Bulger, Brenna Harrington, Josh Krieger, Andrew Latimer, Saman Arbabi, Catherine R. Counts, Michael Sayre, Charles Maynard, Eileen M. Bulger

J Trauma Acute Care Surg. 2021;91(3):457–464.

Background: In addition to reflecting gas exchange within the lungs, end-tidal carbon dioxide (EtCO₂) also reflects cardiac output based on CO₂ delivery to the pulmonary parenchyma. We hypothesized that low prehospital EtCO₂ values would be predictive of hemorrhagic shock in intubated trauma patients. **Methods:** A retrospective observational study of adult trauma patients intubated in the prehospital setting and transported to a single Level I trauma center from 2016 to 2019. Continuous prehospital EtCO₂ data were linked with patient care registries. We developed a novel analytic approach that allows for reflection of prehospital EtCO₂ over the entire prehospital course of care. The primary outcome was hemorrhagic shock on emergency department (ED) presentation, defined as either initial ED systolic blood pressure of 90mmHg or less or initial Shock Index (SI) > 0.9, and transfusion of at least one unit of blood product during their ED stay. Prehospital EtCO₂ less than 25mmHg was evaluated for predictive value of hemorrhagic shock. **Results:** Three hundred and seven patients (82% men, 34% penetrating injury, 42% in hemorrhagic shock on ED arrival, 27% mortality) were included in the study. Patients in hemorrhagic shock had lower median EtCO₂ values (26.5mmHg vs. 32.5mmHg; $p < 0.001$) than those not in hemorrhagic shock. Patients with prehospital EtCO₂ less than 25mmHg were 3.0 times (adjusted odds ratio = 3.0; 95% confidence interval, 1.1–7.9) more likely to be in hemorrhagic shock upon ED arrival than patients with EtCO₂ ≥ 25mmHg. **Conclusion:** Intubated patients with hemorrhagic shock upon ED arrival had significantly lower prehospital EtCO₂ values. Incorporating EtCO₂ assessment into prehospital care for trauma patients could support decisions regarding prehospital blood transfusion, and triage to higher-level trauma centers, and trauma team activation.

An Analysis of Prehospital Trauma Registry After-Action Reviews in Afghanistan

Brandon M. Carius, Peter M. Dodge, Andrew D. Fisher, Paul E. Loos, Dominic Thompson, Steven G. Schauer

J Spec Oper Med. Summer 2021;21(2):49–53.

Background: After-action reviews (AARs) in the Prehospital Trauma Registry (PHTR) enable performance improvements and provide commanders feedback on care delivered at Role 1. No published data exist exploring overall trends of end-user performance-improvement feedback. **Methods:** We performed an

expert panel review of AARs within the PHTR in Afghanistan from January 2013 to September 2014. When possible, we categorized our findings and selected relevant medical provider comments. **Results:** Of 737 registered patient encounters found, 592 (80%) had AAR documentation. Most AAR patients were male (98%, $n = 578$), injured by explosion (48%, $n = 283$), and categorized for urgent evacuation (64%, $n = 377$). Nearly two thirds of AARs stated areas needing improvement (64%, $n = 376$), while the remainder left the improvement section blank (23%, $n = 139$) or specified no improvements (13%, $n = 76$). The most frequently cited areas for improvement were medical knowledge (23%, $n = 136$), evacuation coordination (19%, $n = 115$), and first responder training (16%, $n = 95$). **Conclusion:** Our expert panel reviewed AARs within the PHTR and found substantial numbers of AARs without improvements recommended, which limits quality improvement capabilities. Our analysis supports previous calls for better documentation of medical care in the prehospital combat setting.

Evaluation of the Efficacy of Commercial and Noncommercial Tourniquets for Extremity Hemorrhage Control in a Perfused Cadaver Model

Camilla Cremonini, Nadya Nee, Matthew Demarest, Alice Piccinini, Michael Minneti, Catherine P. Canamar, Elizabeth R. Benjami, Demetrios Demetriades, Kenji Inaba
J Trauma Acute Care Surg. 2021;90(3):522–526.

Background: Tourniquets are a critical tool in the immediate response to life-threatening extremity hemorrhage; however, the optimal tourniquet type and effectiveness of noncommercial devices remain unclear. Our aim was to evaluate the efficacy of five tourniquets in a perfused-cadaver model. **Methods:** This prospective study used a perfused-cadaver model with standardized superficial femoral artery injury bleeding at 700 mL/min. Five tourniquets were tested: combat application tourniquet; rapid application tourniquet system; Stretch, Wrap, and Tuck Tourniquet; an improvised triangle bandage windlass; and a leather belt. Forty-eight medical students underwent a practical hands-on demonstration of each tourniquet. Using a random number generator, they placed the tourniquets on the bleeding cadaver in random order. Time to hemostasis, time to secure devices, estimated blood loss, and difficulty rating were assessed. A one-way repeated measures analysis of variance was used to compare efficacy between the tourniquets in achieving the outcomes. **Results:** The mean \pm SD participant age was 25 ± 2.6 years, and 29 (60%) were male. All but one tourniquet was able to stop bleeding, but the rapid application tourniquet system had a 4% failure rate. Time to hemostasis and estimated blood loss did not differ significantly ($p > 0.05$). Stretch, Wrap, and Tuck Tourniquet required the longest time to be secured (47.8 ± 17.0 seconds), whereas the belt was the fastest (15.2 ± 6.5 seconds; $p < 0.001$). The improvised windlass was rated easiest to learn and apply, with 22 participants (46%) assigning a score of 1. **Conclusion:** Four of five tourniquets evaluated, including both noncommercial devices, effectively achieved hemostasis. A standard leather belt was the fastest to place and was able to stop the bleeding. However, it required continuous pressure to maintain hemostasis. The improvised windlass was as effective as the commercial devices and was the easiest to apply. In an emergency setting where commercial devices are not available, improvised tourniquets may be an effective bridge to definitive care.

23.4% Hypertonic Saline: A Tactical Option for the Management of Severe Traumatic Brain Injury With Impending or Ongoing Herniation

Erik Scott DeSoucy, Kelsey Cacic, Brian P. Staak, Christopher D. Petersen, David van Wyck, Venkatakrishna Rajajee, John Dorsch, Stephen C. Rush
J Spec Oper Med. Summer 2021;21(2):25–28.

There are limited options available to the combat medic for management of traumatic brain injury (TBI) with impending or ongoing herniation. Current pararescue and Tactical Combat Casualty

Care (TCCC) guidelines prescribe a bolus of 3% or 5% hypertonic saline. However, this fluid bears a tactical burden of weight (~570 g) and pack volume (~500 cm³). Thus, 23.4% hypertonic saline is an attractive option, because it has a lighter weight (80 g) and pack volume (55 cm³), and it provides a similar osmotic load per dose. Current literature supports the use of 23.4% hypertonic saline in the management of acute TBI, and evidence indicates that it is safe to administer via peripheral and intraosseous cannulas. Current combat medic TBI treatment algorithms should be updated to include the use of 23.4% hypertonic saline as an alternative to 3% and 5% solutions, given its effectiveness and tactical advantages.

A Case Study of Long-Range Rotary Wing Critical Care Transport in the Battlefield Environment

Jamie Eastman, Jennifer Dumont, Kelly Green
J Spec Oper Med. Summer 2021;21(2):77–79.

Military medical evacuation continues to grow both in distance and transport times. With the need for long-range transport of greater than two hours, crews are having to manage critical care patients for longer trips. This case study evaluates one specific event in which long-range transport of a sick noncombat patient required an enroute critical care team. Medical electronics and other equipment require special attention. Oxygen bottles and batteries for medical devices become the limiting factor in transport from point to point. Having to juggle multiple data streams requires prioritization and reassessment of interventions. Using the mnemonic “bottles, bags, batteries, battlefield environment” keeps the transport paramedic and enroute care nurse on track to effectively deliver the patient to the next level of care. Consideration should be given to such mnemonics for long critical care transports.

Whole Blood at the Tip of the Spear: A Retrospective Cohort Analysis of Warm Fresh Whole Blood Resuscitation Versus Component Therapy in Severely Injured Combat Casualties

Jennifer M. Gurney, Amanda M. Staudt, Deborah J. Del Junco, Stacy A. Shackelford, Elizabeth A. Mann-Salinas, Andrew P. Cap, Philip C. Spinella, Matthew J. Martin
Surgery. 2022;171(2):518–525. Epub 2021 Jul 10.

Background: Death from uncontrolled hemorrhage occurs rapidly, particularly among combat casualties. The US military has used warm fresh whole blood during combat operations owing to clinical and operational exigencies, but published outcomes data are limited. We compared early mortality between casualties who received warm fresh whole blood versus no warm fresh whole blood. **Methods:** Casualties injured in Afghanistan from 2008 to 2014 who received ≥ 2 red blood cell containing units were reviewed using records from the Joint Trauma System Role 2 Database. The primary outcome was 6-hour mortality. Patients who received red blood cells solely from component therapy were categorized as the non-warm fresh whole blood group. Non-warm fresh whole blood patients were frequency-matched to warm fresh whole blood patients on identical strata by injury type, patient affiliation, tourniquet use, prehospital transfusion, and average hourly unit red blood cell transfusion rates, creating clinically unique strata. Multilevel mixed effects logistic regression were adjusted for the matching, immortal time bias, and other covariates. **Results:** The 1,105 study patients (221 warm fresh whole blood, 884 non-warm fresh whole blood) were classified into 29 unique clinical strata. The adjusted odds ratio of 6-hour mortality was 0.27 (95% confidence interval 0.13–0.58) for the warm fresh whole blood versus non-warm fresh whole blood group. The reduction in mortality increased in magnitude (odds ratio = 0.15, $P = 0.024$) among the subgroup of 422 patients with complete data allowing adjustment for seven additional covariates. There was a dose-dependent effect of warm fresh whole blood, with patients receiving higher warm fresh whole blood dose ($> 33\%$ of red blood cell-containing units) having significantly lower mortality versus the non-warm fresh whole blood group. **Conclusion:** Warm

fresh whole blood resuscitation was associated with a significant reduction in 6-hour mortality versus non-warm fresh whole blood in combat casualties, with a dose-dependent effect. These findings support warm fresh whole blood use for hemorrhage control as well as expanded study in military and civilian trauma settings.

The Newest Battlefield Opioid, Sublingual Sufentanil: A Proposal to Refine Opioid Usage in the U.S. Military

Sharon Y. Kim, Chester C. Buckenmaier, Edmund G. Howe, Kwang H. Choi

Mil Med. 2022;187(3-4):77-83. 2021 Sep 29; online ahead of print.

There is an ongoing opioid epidemic in the USA, and the US military is not immune to the health threat. To combat the epidemic, the Department of Defense (DoD) and Department of Veterans' Affairs (DVA) issued new clinical practice guidelines and launched the Opioid Safety Initiative aimed at reducing opioid prescriptions. Furthermore, the DoD continually refined opioid protocols for acute pain on the battlefield, evolving from intramuscular morphine to intravenous morphine administration to oral transmucosal fentanyl citrate lollipops (Actiq) to finally sublingual sufentanil tablets (SSTs, Dsuvia). Interestingly, the newest introduction of SSTs into the military sparked great controversy, as there are concerns over the drug's potential for misuse. However, although the opioid crisis may understandably foster an aversion to new candidate opioids, the therapeutic benefits of effective opioids in acute trauma settings should not be overlooked. SSTs may offer an improved analgesic option to meet the battlefield's unmet needs with its non-invasive, sublingual delivery system and favorable pharmacologic properties that mitigate the risk for side effects, addiction, and adverse outcomes. Accordingly, this commentary aims to (1) review the evolution of opioid use on the battlefield and discuss the medical benefits and limitations of SSTs in acute trauma settings, (2) highlight the importance of chronic pain management post-deployment through evidence-based non-opioid modalities, and (3) explore avenues of future research. Ultimately, we propose that SSTs are an important improvement from existing battlefield opioids and that refining, not abandoning, opioid usage will be key to effectively managing pain in the military.

United States Military Fatalities During Operation New Dawn

Russ S. Kotwal, Edward L. Mazuchowski, Jud C. Janak, Jeffrey T. Howard, Howard T. Harcke, John B. Holcomb, Brian J. Eastridge, Jennifer M. Gurney, Stacy A. Shackelford
J Trauma Acute Care Surg. 2021;91(2):375-383.

Background: Military operations vary by scope, purpose, and intensity, each having unique forces and actions to execute a mission. Evaluation of military operation fatalities guides current and future casualty care. **Methods:** A retrospective study was conducted of all US military fatalities from Operation New Dawn in Iraq from 2010 to 2011. Data were obtained from autopsies and other records. Population characteristics, manner of death, cause of death, and location of death were analyzed. All fatalities were evaluated for concomitant evidence of underlying atherosclerosis. Non-suicide trauma fatalities were also reviewed for injury severity, mechanism of death, injury survivability, death preventability, and opportunities for improvement. **Results:** Of 74 US military Operation New Dawn fatalities (median age, 26 years; male, 98.6%; conventional forces, 100%; prehospital, 82.4%) the leading cause of death was injury (86.5%). The manner of death was primarily homicide (55.4%), followed by suicide (17.6%), natural (13.5%), and accident (9.5%). Fatalities were divided near evenly between combatants (52.7%) and support personnel (47.3%), and between battle injury (51.4%) and disease and nonbattle injury (48.6%). Natural and suicide death was higher ($p < 0.01, 0.02$) among support personnel who were older ($p = 0.05$) with more reserve/national guard personnel ($p = 0.01$). Total population prevalence of underlying atherosclerosis was

18.9%, with more among support personnel (64.3%). Of 46 non-suicide trauma fatalities, most died of blast injury (67.4%) followed by gunshot wound (26.1%) and multiple/blunt force injury (6.5%). The leading mechanism of death was catastrophic tissue destruction (82.6%). Most had nonsurvivable injuries (82.6%) and nonpreventable deaths (93.5%). **Conclusion:** Operation New Dawn fatalities were exclusively conventional forces divided between combatants and support personnel, the former succumbing more to battle injury and the latter to disease and nonbattle injury including self-inflicted injury. For non-suicide trauma fatalities, none died from a survivable injury, and 17.4% died from potentially survivable injuries. Opportunities for improvement included providing earlier blood products and surgery.

Level of evidence: Therapeutic, level V and epidemiological, level IV.

Exploring Tourniquet Conversion in Simulation to Develop Concepts and Hypotheses

John F. Kragh Jr, Tuan D. Le, Michael A. Dubick
J Spec Oper Med. Fall 2021;21(3):23-29.

Background: Compared with those of tourniquet application, tourniquet conversion concepts are underdeveloped. The purpose of this project was to develop tourniquet conversion concepts and generate hypotheses. **Methods:** One person performed 100 tests of tourniquet application and conversion. Testing varied by conversion types, materials, and assessments. Conversions were from improvised or Combat Application Tourniquets (C-A-T) to another C-A-T, a new site (with initial C-A-T only), a pneumatic Emergency and Military Tourniquet (EMT), or a pressure dressing (compression bandage or a roll gauze and an elastic wrap). Simulated limbs were created using plastic bottle-based manikins, pool noodle-based manikins, plastic pipes, glass bottles, a rain downspout, and a cardboard poster tube. **Results:** Tourniquet application, conversion, and total times averaged 105, 132, and 237 seconds, respectively. Improvised tourniquet time was longer than that of C-A-T ($p \leq 0.05$, all three). By initial tourniquet site, the 2-3 inches site had longer conversion and total time ($p \leq 0.02$, both) compared with highest site. By whether initial tourniquets placed were also used in conversion, total time was shorter if yes ($p = 0.05$). Conversion to a pressure dressing was longer in conversion and total time ($p \leq 0.02$, both) compared with conversion to a tourniquet. One wrap was short; we switched to those longer to cover limbs better. Limb types varied for indentation. Conversion communications improved when we used abbreviations and symbols. **Conclusion:** This preliminary project simulated tourniquet conversion to develop clinical concepts and research hypotheses to build a better basis for later research.

Efficacy of Hemostatic Gazes in a Swine Model of Prolonged Field Care With Limb Movement

Grace D. Landers, Cassandra Townsend, Micah Gaspary, Ryan Kachur, Brian Thorne, Sean Stuart, Jose Henao, Gregory J. Zarow, Ramesh Natarajan, Michael Boboc
Mil Med. 2021;186(Suppl 1):384-390.

Introduction: Prolonged field care for junctional wounds is challenging and involves limb movement to facilitate transport. No studies to date have explored the efficacy of gauze products to limit rebleeding in these scenarios. **Materials and Methods:** We randomly assigned 48 swine to QuikClot Combat Gauze, ChitoGauze, NuStat Tactical, or Kerlix treatment groups (12 each) and then inflicted a severe groin injury by utilizing a modified Kheirabadi model of a 6-mm femoral artery punch followed by unrestricted bleeding for 60 seconds. We reassessed rebleed following limb movement at 30 minutes of stabilization and 4 hours after stabilization. **Results:** Swine treated with Combat Gauze proved to have the lowest incidence of rebleeding, and conversely, NuStat Tactical had the highest incidence of rebleeding at wounds after limb movement. Importantly, rebleeds occurred at a rate of 25-58% across all swine treatment groups at 30 minutes postinjury and 0-42% at 270 minutes postinjury, demonstrating that limb movements universally

challenge hemostatic junctional wounds. **Conclusion:** Our findings highlight the difficulty of controlling hemorrhage from junctional wounds with hemostatic gauze in the context of prolonged field care and casualty transport. Our research can guide selection of hemorrhage control gauze when patients have prolonged field extraction or difficult transport. Our data demonstrates the frequency of junctional wound rebleeding after movement and thus the importance of frequent patient reassessment.

Determining a Need for Point-of-Care Ultrasound in Helicopter Emergency Medical Services Transport

Timothy J. Lenz, Mary Beth Phelan, Tom Grawey
Air Med J. 2021;40(3):175–178.

Objective: Point-of care-ultrasound (PoCUS) is useful in evaluating unstable emergency department patients. The portability of this technology increases its potential use in prehospital settings, including helicopter emergency medical services (HEMS) programs. Identifying useful applications may support implementing a PoCUS program that develops sonography skills for prehospital providers. The aim of this study was to determine the HEMS patient population that would benefit from prehospital PoCUS for hypotension and how commonly the extended focused assessment with sonography in trauma (E-FAST) for trauma patients or the rapid ultrasound in shock (RUSH) for medical patients could be used by HEMS. **Methods:** A retrospective chart review was performed over a 1-year period of adult patients transported by a midwestern HEMS system. Charts were reviewed for episodes of hypotension. **Results:** The chart review included 216 charts, of which 3 were excluded. Of the 213 cases, 100 were trauma patients, and 113 were medical patients. Of the trauma patients, 51% experienced hypotension, as did 73 of 113 medical patients. **Conclusion:** Fifty percent of HEMS patients may benefit from PoCUS to evaluate for hypotension in flight.

Ketamine Use in Operation Enduring Freedom

Eric Leslie, Eric Pittman, Brendon Drew, Benjamin Walrath
Mil Med. 2021;186(7-8):e720–e725.

Introduction: Ketamine is a dissociative anesthetic increasingly used in the prehospital and battlefield environment. As an analgesic, it has been shown to have comparable effects to opioids. In 2012, the Defense Health Board advised the Joint Trauma System to update the Tactical Combat Casualty Care Guidelines to include ketamine as an acceptable first line agent for pain control on the battlefield. The goal of this study was to investigate trends in the use of ketamine during Operation Enduring Freedom (OEF) and Operation Freedom's Sentinel (OFS) during the years 2011–2016. **Materials and Methods:** A retrospective review of Department of Defense Trauma Registry (DoDTR) data was performed for all patients receiving ketamine during OEF/OFS in 2011–2016. Prevalence of ketamine use, absolute use, mechanism of injury, demographics, injury severity score, provider type, and co-administration rates of various medications and blood products were evaluated. **Results:** Total number of administrations during the study period was 866. Ketamine administration during OEF/OFS increased during the years 2011–2013 (28 patient administrations in 2011, 264 administrations in 2012, and 389 administrations in 2013). A decline in absolute use was noted from 2014 to 2016 (98 administrations in 2014, 41 administrations in 2015, and 46 administrations in 2016). The frequency of battlefield ketamine use increased from 0.4% to 11.3% for combat injuries sustained in OEF/OFS from 2011 to 2016. Explosives (51%) and penetrating trauma (39%) were the most common pattern of injury in which ketamine was administered. Ketamine was co-administered with fentanyl (34.4%), morphine (26.2%), midazolam (23.1%), tranexamic acid (12.3%), plasma (10.3%), and packed red blood cells (18.5%). **Conclusion:** This study demonstrates increasing use of ketamine by the US military on the battlefield and effectiveness of clinical practice guidelines in influencing practice patterns.

Efficacy of Commercial Chest Seal Adherence and Tension Pneumothorax Prevention: A Systematic Review of Quantitative Studies

Roland Paquette, Meredith Quinene, Lorne H. Blackbourne, Paul B. Allen

J Spec Oper Med. Fall 2021;21(3):78–85.

Background: Penetrating thoracic injuries account for an essential subset of battlefield and civilian injuries that result in death. Current recommendations are to use commercially available nonocclusive chest seals. We review current evidence for which chest seal(s) is likely to be the most effective in treating open pneumothoraces. **Methods:** A systematic review was conducted in accordance with the PRISMA 2009 standard systematic review methodology, except where noted. The databases PubMed, MEDLINE, CINAHL, Scopus, and gray sources were searched for all English-language, full-manuscript, experimental, quantitative studies of humans and animals concerning seal adherence or their efficacy at preventing tension pneumothoraces published between 1990 and 2020. A numerical analysis was used to provide the consensus recommendation. **Results:** Of 683 eligible identified articles [PubMed 528 (77.3%), Scopus 87 (12.7%), CINAHL 67 (9.8%), one (0.1%) unpublished], six (0.9%) articles were included. Synthesis of all studies' results suggested a consensus recommendation for the Hyfin Vent Chest Seal and Russell Chest Seal. These two were the most effective chest seals, as previously investigated in a quantifiable, experimental study. **Conclusion:** While chest seals are recommended in civilian and military prehospital medicine to improve patient survival, current evidence concerning the individual device's efficacy is limited. Further scientific, quantitative research is needed to clarify which commercially available chest seals are most effective and provide patients with penetrating chest trauma the best possible method for preventing or mitigating tension pneumothoraces.

Blood Product Administration During Transport Throughout the US Africa Command Theater of Operation

Steven G. Schauer, Jason F. Naylor, Andrew D. Fisher, Darren G. Hyams, Brandon M. Carius, Mireya A. Escandon, Carlissa D. Linscomb, Harry McDonald, Andrew P. Cap, James Bynum

J Spec Oper Med. Fall 2021;21(3):66–70.

Background: United States Africa Command (US AFRICOM) is one of six US Defense Department's geographic combatant commands and is responsible to the Secretary of Defense for military relations with African nations, the African Union, and African regional security organizations. A full-spectrum combatant command, US AFRICOM is responsible for all US Department of Defense operations, exercises, and security cooperation on the African continent, its island nations, and surrounding waters. We seek to characterize blood product administration within AFRICOM using the in-transit visibility tracking tool known as TRAC2ES (TRANSCOM Regulating and Command & Control Evacuation System). **Methods:** We performed a retrospective review of TRAC2ES medical evacuations from the AFRICOM theater of operations conducted between 1 January 2008 and 31 December 2018. **Results:** During this time, there were 963 cases recorded in TRAC2ES originating within AFRICOM, of which 10 (1%) cases received blood products. All patients were males. One was a Department of State employee, one was a military working dog, and the remainder were military personnel. Of the ten humans, seven were the result of trauma, most by way of gunshot wound, and three were due to medical causes. Among human subjects receiving blood products for traumatic injuries, a total of 5 units of type O negative whole blood, 29 units of packed red blood cells (pRBCs), and 9 units of fresh frozen plasma (FFP) were transfused. No subjects underwent massive transfusion of blood products, and only one subject received pRBCs and FFP in 1:1 fashion. All subjects survived until evacuation. **Conclusion:** Within the TRAC2ES database, blood product administration within AFRICOM was infrequent, with some cases highlighting lack of access to adequate

blood products. Furthermore, the limitations within this database highlight the need for systems designed to capture medical care performance improvement, as this database is not designed to support such analyses. A mandate for performance improvement within AFRICOM that is similar to that of the US Central Command would be beneficial if major improvements are to occur.

Studies on the Correct Length of Nasopharyngeal Airways in Adults: A Literature Review

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The use of a nasopharyngeal airway (NPA) as an adjunct airway device can be critically important in emergency medicine. When placed correctly, the device can prevent upper airway obstruction. The goal of our review was to learn whether there is scientific evidence about the correct length and the insertion depth, and possible facial landmarks, that can predict the appropriate length of the NPA. There has been no real consensus on how to measure the appropriate tube length for the NPA. Several studies have been able to demonstrate correlations between facial landmarks and body dimensions; however, we did not find any scientific evidence on this matter. The reviewed studies do not indicate evidence to support current recommended guidelines. This could potentially lead to both military and civilian emergency training programs not having the most accurate scientific information for training on anatomic structures, and not having a better overall understanding of intraoral dimensions. Emergency personnel should be taught validated scientific knowledge of NPAs so as to quickly determine the correct tube length and how to use anatomic correlations. This might require further studies on the correlations and perhaps radiographic measurements. A further approach includes adjusting the tube to its correct length according to the sufficient assessment and management of the airway problem.

Implementation and Evaluation of Tactical Combat Casualty Care for Army Aviators

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Mil Med. 2020;185(7-8):e1271–e1276.

Introduction: The importance of developing military strategies to decrease preventable death by mitigating hemorrhage and reducing time between the point of injury and surgical intervention on the battlefield is highlighted in previous studies. Successful implementation of Tactical Combat Casualty Care (TCCC) throughout elements of the USA and allied militaries begins to address this need. However, TCCC implementation is neither even nor complete in the larger, conventional force. Army Aviators are at risk for preventable death as they do not receive prehospital care training and are challenged to render prehospital care in the austere environment of helicopter operations. Army aviators are at risk for preventable death due to the challenges to render prehospital care in the austere environment of helicopter operations. Helicopters often fly at low altitudes, engage in direct action in support of ground troops, operate at a great distance from medical facilities, typically do not have medical personnel onboard, and can have long wait times for medical evacuation services due to the far forward nature of helicopter operations. **Materials and Methods:** This is a quality improvement pre-post-intervention design study evaluating the implementation of a combat casualty care training program for Army aviators using well-established evidence-based guidelines for providing care to casualties on the battlefield. The evaluation consisted of participants' self-perceived confidence in providing care to a casualty and change in knowledge level in combat casualty care in a pre/post-intervention design. Clinical skills of tourniquet application, nasopharyngeal airway placement, and needle chest decompression were assessed on a pass/fail grading standard. **Results:** A total of 18 participants completed the pre- and post-education surveys. A paired t-test showed a statistically significant increase in total composite scores from pre ($M = 24.67$,

$SD = 5.06$) to post-education self-efficacy ($M = 37.94$, $SD = 2.10$), $t(17) = -11.29$, $p < 0.001$. A paired t-test revealed a significant increase in exam scores from pre ($M = 70.22$, $SD = 9.43$) to post ($M = 87.78$, $SD = 7.19$), $t(17) = -7.31$, $p < 0.001$. There was no pre-intervention skills assessment, however, all participants ($n = 18$, 100%) passed the tourniquet application, needle chest compression, and insertion of nasopharyngeal airway. **Conclusion:** TCCC for Army Aviators is easily implemented, demonstrates an increase in knowledge and confidence in providing prehospital care, and provides effective scenario-based training of necessary psychomotor skills needed to reduce preventable death on the battlefield. TCCC for Army Aviators effectively takes the TCCC for All Combatants curriculum and modifies it to address the unique considerations in treating wounded aviators and passengers, both in flight and after crashes. This project demonstrates on a small scale how TCCC can be tailored to specific military jobs in order to successfully meet the intent of the upcoming All Service Member TCCC course mandated in DoD 1322.24. Beyond Army aviation, this program is easily modifiable for aviators throughout the military and civilian sector.

Prehospital Paramedic Pleural Decompression: A Systematic Review

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Injury. 2021;52(10):2778–2786.

Background: Tension pneumothorax (TPT) is a frequent life-threatening following thoracic injury. Time-critical decompression of the pleural cavity improves survival. However, whilst paramedics utilize needle thoracostomy (NT) and/or finger thoracostomy (FT) in the prehospital setting, the superiority of one technique over the other remains unknown. **Aim:** To determine and compare procedural success, complications, and mortality between NT and FT for treatment of a suspected TPT when performed by paramedics. **Methods:** We searched four databases (Ovid Medline, PubMed, CINAHL and Embase) from their commencement until 25 August 2020. Studies were included if they analyzed patients suffering from a suspected TPT who were treated in the prehospital setting with a NT or FT by paramedics (or local equivalent nonphysicians). **Results:** The search yielded 293 articles after duplicates were removed of which 19 were included for final analysis. Seventeen studies were retrospective (8 cohort; 7 case series; 2 case control) and two were prospective cohort studies. Only one study was comparative, and none were randomized controlled trials. Most studies were conducted in the USA ($n = 13$) and the remaining in Australia ($n = 4$), Switzerland ($n = 1$) and Canada ($n = 1$). Mortality ranged from 12.5% to 79% for NT and 64.7% to 92.9% for FT patients. A higher proportion of complications were reported among patients managed with NT (13.7%) compared to FT (4.8%). We extracted three common themes from the papers of what constituted as a successful pleural decompression: vital signs improvement, successful pleural cavity access, and absence of TPT at hospital arrival. **Conclusion:** Evidence surrounding prehospital pleural decompression of a TPT by paramedics is limited. Available literature suggests that both FT and NT are safe for pleural decompression, however both procedures have associated complications. Additional high-quality evidence and comparative studies investigating the outcomes of interest is necessary to determine if and which procedure is superior in the prehospital setting.

Evaluating the Tactical Combat Casualty Care Principles in Civilian and Military Settings: Systematic Review, Knowledge Gap Analysis and Recommendations for Future Research

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Trauma Surg Acute Care Open. 2021;6(1):e000773.

Objectives: The Tactical Combat Casualty Care (TCCC) guidelines detail resuscitation practices in prehospital and austere environments. We sought to review the content and quality of the current TCCC and civilian prehospital literature and characterize knowledge gaps to offer recommendations for future research. **Methods:** MEDLINE, EMBASE, CINAHL, and Cochrane Central Register of Controlled Trials were searched for studies assessing intervention techniques and devices used in civilian and military prehospital settings that could be applied to TCCC guidelines. Screening and data extraction were performed according to PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines. Quality appraisal was conducted using appropriate tools. **Results:** Ninety-two percent (n = 57) of studies were observational. Most randomized trials had low risk of bias, whereas observational studies had higher risk of bias. Interventions of massive hemorrhage control (n = 17) were wound dressings and tourniquets, suggesting effective hemodynamic control. Airway management interventions (n = 7) had high success rates with improved outcomes. Interventions of respiratory management (n = 12) reported low success with needle decompression. Studies assessing circulation (n = 18) had higher quality of evidence and suggested improved outcomes with component hemostatic therapy. Hypothermia prevention interventions (n = 2) were generally effective. Other studies identified assessed the use of extended focused assessment with sonography in trauma (n = 3) and mixed interventions (n = 2). **Conclusion:** The evidence was largely non-randomized with heterogeneous populations, interventions, and outcomes, precluding robust conclusions in most subjects addressed in the review. Knowledge gaps identified included the use of blood products and concentrate of clotting factors in the prehospital setting.

Between the Devil and the Deep Blue Sea: A Review of 25 Modern Naval Mass Casualty Incidents With Implications for Future Distributed Maritime Operations

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J Trauma Acute Care Surg. 2021;91(2S Suppl 2):S46–S55.

In the future, United States Navy Role 1 and Role 2 shipboard medical departments will be caring for patients during Distributed Maritime Operations in both contested and noncontested austere environments, likely for prolonged periods of time. This literature review examines 25 modern naval mass casualty incidents over a 40-year period representative of naval warfare, routine naval operations, and ship-based health service support of air and land operations. Challenges, lessons learned, and injury patterns are identified to prepare afloat medical departments for the future fight.

A Comparison of Efficacy, Efficiency, and Durability in Novel Tourniquet Designs

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J Trauma Acute Care Surg. 2021;91(2S Suppl 2):S139–S145.

Background: Exsanguination due to extremity hemorrhage is a major cause of preventable traumatic deaths. Extremity tourniquet use has been shown to be safe and improve survival. The purpose of this study was to compare the efficacy, efficiency, and durability of the Generation 7 Combat Application Tourniquet (CAT; North American Rescue, Greer, SC), the Tactical Mechanical Tourniquet (TMT; Combat Medical Systems, Harrisburg,

NC), and the Special Operations Forces (SOF) Tactical Tourniquet-Wide (SOFTT-W; Tactical Medical Solutions, Anderson, SC). **Methods:** This study was a three-phase randomized, cross-over trial. In successive trials, subjects were timed during the application of each tourniquet to the upper and lower extremity. Following successful lower extremity application, subjects low crawled 25 ft and then were dragged 25 ft, after which effectiveness was reassessed, as defined by the cessation of distal pulses by Doppler ultrasound. **Results:** In arm application, both the CAT and TMT had significantly less failure rates than the SOFTT-W (5.56%, 19.44%, 58.33%), with the CAT being the fastest tourniquet when compared with TMT and SOFTT-W (37.8 seconds, 65.01 seconds, 63.07 seconds). In leg application, the CAT had significantly less rates of failure when compared with the SOFTT-W, but there was no other significant difference between the tourniquets (27.78%, 44.44%, 61.11%). In addition, the CAT was significantly faster than both the TMT and SOFTT-W when applied to the leg (8.33 seconds, 40.96 seconds, 34.5 seconds). There was no significant difference in tourniquet failure rates between the three tourniquets after subject maneuvers in phase 3 (34.29%, 42.86%, 45.45%). **Discussion:** The CAT is as effective as the TMT and significantly more effective than the SOFTT-W. In addition, the CAT demonstrated shorter application times than either the TMT or SOFTT-W. However, there was no significant difference between the three tourniquets in their ability to maintain pulselessness after subject maneuvers.

The Role of Plasma Transfusion in Pre-Hospital Haemostatic Resuscitation

Harriet Tucker, Ross Davenport, Laura Green
Transfusion Med Rev. 2021;35(4):91–95.

Traumatic hemorrhage remains a major cause of preventable death and early hemostatic resuscitation is now a mainstay of treatment internationally. Recently, two randomized control trials (RCTs) – PAMPer (Prehospital Air Medical Plasma) and COMBAT (Control of Major Bleeding After Trauma), evaluating the effect of pre-hospital use of plasma on mortality provided conflicting results, raising important questions on the role of plasma resuscitation in pre-hospital environment. Both PAMPer (n = 501 patients) and COMBAT (n = 144 patients) trials were pragmatic RCTs that evaluated the effect of pre-hospital plasma transfusion (two units) versus standard of care on 28/30 days mortality in trauma patients who presented with clinical signs of hemorrhagic shock (defined as hypotension or tachycardia). The PAMPer trial showed that plasma transfusion reduced 30-day mortality compared with standard of care (23% vs. 33%, 95% confidence interval –18.6; –1.0%; $P = 0.03$), while COMBAT trial showed no difference in 28-day survival. The post-hoc analyses of the two trials have suggested that the benefit of pre-hospital plasma transfusion may be greater for patients who are coagulopathic, have blunt injury, and have a transport time from the scene of injury to the hospital of > 20 minutes. In this review we evaluate strengths and limitations of the two trials and their differences and similarities, which may explain the conflicting results, as well as provide directions for future trials to better define the target population that would most benefit from pre-hospital plasma resuscitation. Further, considering the logistical challenges of carrying any blood components on an aircraft, cost/safety of plasma, and the scarcity of universal blood group donors, there is a need for a health economic evaluation of pre-hospital plasma transfusion in trauma patients, prior to this intervention becoming universal.



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