

## Tactical Combat Casualty Care & En Route Combat Casualty Care Selected Abstracts from 2024

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The Committee on Tactical Combat Casualty Care (CoTCCC) is the branch of the Joint Trauma System (JTS) focused on the standard of care for prehospital battlefield medicine. The Committee on En Route Combat Casualty Care (CoERCCC) is the branch of the JTS focused on the standard of care for en route care through the evacuation echelons of care. The JTS is the Department of Defense Center of Excellence for Trauma and division of the Defense Health Agency (DHA) that provides clinical practice guidelines and performance improvement for all levels of military trauma care.

The CoTCCC and CoERCCC maintain a monthly journal watch to maintain awareness of published medical evidence relevant to the ongoing review of TCCC and ERCCC Guidelines, training, and practices. The committees conduct searches based on over 100 keywords and screen abstracts for current change proposals or potential proposed changes for lead authors. In 2024, there were 2,190 abstracts found in searches of which 331 were identified to be included in the journal watch. Below is a sampling of those relevant articles from the last year. The leadership of the committees highly recommends these selected articles as highlighted reading for prehospital medical directors, unit medical officers, senior medics, and combat casualty care instructors.

Posting of articles does not imply agreement or disagreement with the contents nor does it constitute a change in TCCC or ERCCC guidelines, practices, or training.

**Interventions Associated with Survival After Prehospital Intubation in the Deployed Combat Setting**  
*Am J Emerg Med.* 2024;79:79–84.  
doi:10.1016/j.ajem.2024.01.047

Michael D. April, Rachel E. Bridwell, William T. Davis, Joshua J. Oliver, Brit Long, Andrew D. Fisher, Adit A. Ginde, Steven G. Schauer

**Introduction:** Airway compromise is the second leading cause of potentially preventable death on the battlefield. Prehospital airway management is often unavoidable in a kinetic combat environment and expected to increase in future wars where timely evacuation will be unreliable and air superiority not guaranteed. We compared characteristics of survivors to non-survivors among combat casualties undergoing prehospital airway intubation.

**Materials and methods:** We requested all Department of Defense Trauma Registry (DODTR) encounters during 2007–2023 with documentation of any airway intervention or

assessment within the first 72-h after injury. We conducted a retrospective cohort study of all casualties with intubation documented in the prehospital setting. We used descriptive and inferential statistical analysis to compare survivors through 7 days post injury versus non-survivors. We constructed 3 multivariable logistic regression models to test for associations between interventions and 7-day survival after adjusting for injury severity score, mechanism of injury, and receipt of sedatives, paralytics, and blood products.

**Results:** There were 1377 of 48,301 patients with documentation of prehospital intubation in a combat setting. Of these, 1028 (75%) survived through 7 days post injury. Higher proportions of survivors received ketamine, paralytic agents, parenteral opioids, and parenteral benzodiazepines; there was no difference in the proportions of survivors versus non-survivors receiving etomidate. The multivariable models consistently demonstrated positive associations between 7-day survival and receipt of non-depolarizing paralytics and opioid analgesics.

**Conclusions:** We found an association between non-depolarizing paralytic and opioid receipt with 7-day survival among patients undergoing prehospital intubation. The literature would benefit from future multi-center randomized controlled trials to establish optimal pharmacologic strategies for trauma patients undergoing prehospital intubation.

**A Scoping Review of Military Combat Casualty Data on Submassive, Massive, and Supermassive Transfusions**  
*Mil Med.* 2025;190(1-2):e99–e106.  
doi:10.1093/milmed/usae349

Rohan C. Banerjee, Jasmine A. Castillejos, Sean P. Krewson, Karen R. Mina, Andrew D. Fisher, Michael D. April, Steven G. Schauer

**Introduction:** Blood transfusions are common during combat casualty care, aiming to address the loss of blood volume that often accompanies severe battlefield injuries. This scoping review delves into the existing military combat casualty data to analyze the efficacy, challenges, and advances in the use of massive and super-massive transfusions in the management of critically injured warfighters.

**Materials and methods:** We performed a scoping review of combat-related literature published between 2006 and 2023 pertaining to massive transfusions used during combat deployments. We utilized PubMed to identify relevant studies and utilized the PRISMA-ScR Checklist to conduct the review.

**Results:** We identified 53 studies that met the inclusion criteria with the majority being retrospective studies from registries

used by the United States, British, French, and Dutch Militaries. Most of the studies focused on transfusion ratios, the movement of blood transfusions to more forward locations, implementation of massive transfusions with different fibrinogen-to-red blood cell ratios, the addition of recombinant factor VII, and the use of predictive models for transfusion. Lastly, we identified reports of improved survival for casualties with the rapid implementation of various blood products (warm fresh whole blood, cold-stored low titer group O blood, freeze-dried plasma, and component therapy) and literature relating to pediatric casualties and submassive transfusions. Notable findings include the establishment of hemodynamic and cell blood count parameters as predictors of the requirement for massive transfusions and the association of higher fibrinogen-to-red blood cell ratios with decreased mortality.

**Conclusions:** We identified 53 studies focused on blood transfusions from the Global War on Terrorism conflicts. The majority were related to transfusion ratios and the movement of blood transfusions to more forward locations. We highlight key lessons learned on the battlefield that have been translated into scientific developments and changes in civilian trauma methods.

#### Injury Trends Aboard US Navy Vessels: A 50-year Analysis of Mishaps at Sea

*J Trauma Acute Care Surg.* 2023;95(2S Suppl 1):S41–S49.  
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**Background:** Maritime activities have been associated with unique dangers to civilian and military sailors. We performed a retrospective cohort study analyzing injury mechanisms and clinical outcomes of casualties onboard US naval ships to determine common injury mechanisms, trends, and outcomes. We hypothesized there would be a downward trend of injuries and fatalities on US naval ships during the study period.

**Methods:** All mishaps recorded by the Naval Safety Command aboard active service US naval ships from 1970 through 2020 were reviewed. Only mishaps resulting in injury or fatality were included. Over time, injury mechanisms and casualty incidence rates were trended and compared based on medical capabilities. Ships without surgical capabilities were categorized as Role 1, and those with surgical capabilities as Role 2.

**Results:** There were a total of 3,127 casualties identified and analyzed, with 1,048 fatalities and 2,079 injuries. The injury mechanisms associated with the highest mortality included electrocution, blunt head trauma, fall from height, man overboard, and explosion. There was a decrease in the trend of mishaps resulting in casualties, fatalities, and injuries over the 50-year study period. The mortality rate for select severe injury mechanisms was higher on Role 1 capable platforms, compared with Role 2 (0.334 vs. 0.250,  $p < 0.05$ ).

**Conclusion:** Casualty incidences decreased over 50 years. However, mortality still remains high for certain mechanisms no matter the operational platform. Furthermore, Role 1 capable vessels have a higher overall mortality rate for severe injuries compared with Role 2. The authors propose training, process improvement, and technology-related solutions to improve outcomes on Role 1 capable naval vessels.

#### Who Needs a Tourniquet? And Who Does Not?

#### Lessons Learned From a Review of Tourniquet Use in the Russo-Ukrainian War

*J Trauma Acute Care Surg.* 2024;97(2S Suppl 1):S45–S54.  
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**Background:** Extremity tourniquets have proven to be lifesaving in both civilian and military settings and should continue to be used by first responders for trauma patients with life-threatening extremity bleeding. This is especially true in combat scenarios in which both the casualty and the first responder may be confronted by the imminent threat of death from hostile fire as the extremity hemorrhage is being treated. Not every extremity wound, however, needs a tourniquet. One of the most important aspects of controlling life-threatening extremity bleeding with tourniquets is to recognize what magnitude of bleeding requires this intervention and what magnitude of bleeding does not. Multiple studies, both military and civilian, have shown that tourniquets are often applied when they are not medically indicated. Overuse of extremity tourniquets has not caused excess morbidity in either the recent conflicts in Iraq and Afghanistan or in the US urban civilian setting. In the presence of prolonged evacuation, however, applying a tourniquet when it is not medically indicated changes tourniquet application from being a lifesaving intervention to one that may cause an avoidable amputation and the development of an array of metabolic derangements and acute kidney injury collectively called prolonged tourniquet application syndrome.

**Methods:** The recent literature was reviewed for papers that documented the complications of tourniquet use resulting from the prolonged casualty evacuation times being seen in the current Russo-Ukrainian war. The literature was also reviewed for the incidence of tourniquet application that was found to not be medically indicated, in both the US civilian setting and from Ukraine. Finally, an in-person meeting of the US/Ukraine Tourniquet Working Group was held in Warsaw, Poland, in December of 2023.

**Results:** Unnecessary loss of extremities and life-threatening episodes of prolonged tourniquet application syndrome are currently occurring in Ukrainian combat forces because of non-indicated tourniquet use combined with the prolonged evacuation time seen in the Russo-Ukrainian war. Specific numbers of the complications experienced as a result of tourniquet use by Ukrainian forces in the current conflict are treated as classified information and are not available, but multiple sources from the Ukrainian military medical personnel and from the US advisors providing medical assistance to Ukraine have all agreed that the problem is substantial.

**Conclusion:** Unnecessary tourniquet morbidity might also occur in US forces in a variety of potential future combat scenarios in which evacuation to surgical care is delayed. Prehospital trauma training programs, including but not limited to tactical combat casualty care, place insufficient emphasis on the need to avoid leaving tourniquets in place when they are not medically indicated. This aspect of training should receive emphasis in future Tactical Combat Casualty Care (TCCC) and civilian first responder curriculum development. An interim ad

hoc training solution on this topic is available at the websites noted in this articles. Additional training modalities may follow in the near future.

### Prescreened Whole O Blood Group Walking Blood Bank Capabilities for Nontraditional Maritime Medical Receiving Platforms: A Case Series

*J Spec Oper Med.* Published online March 13, 2024.  
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**Background:** Tactical Combat Casualty Care (TCCC) guidelines recognize low-titer group O whole blood (LTOWB) as the resuscitative fluid of choice for combat wounded. Utilization of prescreened LTOWB in a walking blood bank (WBB) format has been well described by the Ranger O low-titer blood (ROLO) and the United States Marine Corps Valkyrie programs, but it has not been applied to the maritime setting.

**Methods:** We describe three WBB experiences of an expeditionary resuscitative surgical system (ERSS) team, attached to three nontraditional maritime medical receiving platforms, over 6 months.

**Results:** Significant variations were identified in the number of screened eligible donors, the number of LTOWB donors, and the timely arrival at WBB activation sites between the platforms. Overall, 95% and 84% of the screened eligible group O blood donors on the Arleigh Burke Class Destroyer (DDG) and Nimitz Class Aircraft Carrier (CVN), respectively, were determined to be LTOWB. However, only 37% of the eligible screened group O blood donors aboard the Harper's Ferry Class Dock Landing Ship (LSD) were found to be LTOWB. Of the eligible donors, 66% did not complete screening, with 52% citing a correctable reason for nonparticipation.

**Conclusion:** LTOWB attained through WBBs may be the only practical resuscitative fluid on maritime platforms without inherent blood product storage capabilities to perform remote damage control resuscitation. Future efforts should focus on optimizing WBBs through capability development, education, and training efforts.

### Expectant Casualty Care Training Needs for Future Conflicts

*Mil Med.* 2025;190(3-4):e797–e803.  
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Rebekah Cole, Sean Keenan, Matthew D Tadlock, Shawna Grover, Melissa Givens, Sherri L. Rudinsky

**Introduction:** The demands of future large-scale combat operations may require medics and corpsmen to increasingly perform expectant casualty care (ECC). However, no detailed guidelines currently exist for providing ECC within military medicine. To guide the development of education and training guidelines and advance team training of both medics and non-medics, an in-depth understanding is first needed regarding caregivers' experiences providing ECC in recent conflicts as well as perceived training gaps. Therefore, this study explored the experiences of medics and physicians providing ECC and investigated their perceptions of training needs in this area for future conflicts characterized by large-scale combat operations and prolonged casualty care operational settings.

**Materials and methods:** We conducted an engaged qualitative phenomenological study to explore ECC training needs for future conflicts. We interviewed 9 senior health care professionals (medics and physicians) who had extensive combat and deployment experiences and served primarily in the Role 1 environment. The interviews averaged 45 min each and were conducted via phone. To analyze this interview data, we reviewed the interview transcripts and then noted terms, phrases, and concepts within the interview transcripts that we found to be salient to answering the research question. Our team then met to review these codes and grouped them into categories. These categories served as the themes of this study that illustrated the participants' perceptions and experiences.

**Results:** Five themes emerged from our data: (1) There is a current gap in ECC training for enlisted Role 1 caregivers throughout the military; (2) ECC training is needed to shift organizational culture; (3) ECC training should be comprehensive; (4) ECC training should be deliberate; and (5) Time is the greatest challenge to implementing ECC training. Our participants noted that developing guidelines and filling training gaps is not only critical for preparing Role 1 providers for effective and ethical military medical decision-making but also for addressing death and dying on the battlefield and building moral resilience across the medical corps.

**Conclusion:** Our results provide direction for development of ECC clinical guidance and collective team training recommendations. Following these guidelines may increase life-saving capabilities on the far-forward battlefield and equip medical directors and medics to provide ethical and compassionate care to those who cannot be saved in the setting of limited resources and evacuation opportunities.

### An Analysis of Tube Thoracostomy in Combat Implications for Improved Prehospital Recognition and Treatment

*J Spec Oper Med.* 2024;24(2):17–21.  
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**Background:** Thoracic trauma occurs frequently in combat and is associated with high mortality. Tube thoracostomy (chest tube) is the treatment for pneumothorax resulting from thoracic trauma, but little data exist to characterize combat casualties undergoing this intervention. We sought to describe the incidence of these injuries and procedures to inform training and materiel development priorities.

**Methods:** This is a secondary analysis of a Department of Defense Trauma Registry (DoDTR) data set from 2007 to 2020 describing prehospital care within all theaters in the registry. We described all casualties who received a tube thoracostomy within 24 hours of admission to a military treatment facility. Variables described included casualty demographics; abbreviated injury scale (AIS) score by body region, presented as binary serious (≥3) or not serious (<3); and prehospital interventions.

**Results:** The database identified 25,897 casualties, 2,178 (8.4%) of whom received a tube thoracostomy within 24 hours of admission. Of those casualties, the body regions with the highest proportions of common serious injury (AIS ≥3) were thorax 62% (1,351), extremities 29% (629), abdomen 22% (473), and head/neck 22% (473). Of those casualties,



13% (276) had prehospital needle thoracostomies performed, and 19% (416) had limb tourniquets placed. Most of the patients were male (97%), partner forces members or humanitarian casualties (70%), and survived to discharge (87%).

**Conclusions:** Combat casualties with chest trauma often have multiple injuries complicating prehospital and hospital care. Explosions and gunshot wounds are common mechanisms of injury associated with the need for tube thoracostomy, and these interventions are often performed by enlisted medical personnel. Future efforts should be made to provide a correlation between chest interventions and pneumothorax management in prehospital thoracic trauma.

#### Low-dose Ketamine for Acute Pain: A Narrative Review

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**Introduction:** Acute pain management is a critical component of prehospital and emergency medical care. Opioids are effective; however, the risks and side-effects of opioids have led providers to use low-dose ketamine (LDK) for safe and effective treatment of acute pain.

**Methods:** We conducted a scoping narrative review to explore the efficacy of LDK for the treatment of acute pain in the prehospital setting and emergency department (ED) setting. The prehospital review includes studies evaluating the use of LDK in both civilian and military settings. We utilized PubMed to identify prospective and retrospective clinical studies related to this topic. We limited study inclusion to quality prospective and retrospective clinical and observational studies published in the English language prior to January 30, 2024. We did not limit study inclusion based on patient population or mode of administration. We utilized the PRISMA-ScR checklist to conduct this review.

**Results:** Using our methodology, we found 249 publications responsive to our search strategy. Of these, 178 publications were clearly outside inclusion criteria based on abstract review. Seventy-one studies were sought for retrieval and more detailed review. Of these, 22 records were excluded after review and 43 met initial inclusion criteria. An additional 22 studies were found via snowballing. In total, 64 studies met inclusion criteria for this analysis. 21 studies related to the treatment of acute pain in the prehospital setting, four of which were randomized clinical trials (RCTs). Forty-three studies evaluate the treatment of acute pain in the ED. This included 28 RCTs. Taken together, the studies suggest that LDK is non-inferior to opioids when used alone. When used as an adjunct to opioid therapy, LDK can provide an opioid-sparing effect. Ketamine doses <0.5 mg/kg were not associated with significant side effects.

**Conclusions:** LDK is a safe and effective option for acute pain treatment. It can be used as an alternative therapy to opioids or used in conjunction with them to reduce opioid exposure through its opioid-sparing effect. Importantly, LDK is available in a variety of formulations including intramuscular, intravenous, and intranasal, making it an effective acute pain treatment option in both the prehospital and ED settings. LDK holds promise as an emergency treatment in the evolving landscape of acute pain management.

#### Rethinking Limb Tourniquet Conversion in the Prehospital Environment

*J Trauma Acute Care Surg.* 2023;95(6):e54–e60.

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John B. Holcomb, Warren C. Dorlac, Brendon G. Drew, Frank K. Butler, Jennifer M. Gurney, Harold R. Montgomery, Stacy A. Shackelford, Eric A. Bank, Jeff D. Kerby, John F. Kragh, Michael A. Person, Jessica L. Patterson, Olha Levchuk, Mykola Andriiievskyi, Glib Bitiukov, Oleksandr Danyljuk, Oleksandr Linchevskyy

We have highlighted the issue of overuse of tourniquets and described why tourniquet conversion and replacement should be taught and done in the prehospital setting.

#### Lessons Learned by the 75th Ranger Regiment during Twenty Years of Tactical Combat Casualty Care

*Military Review.* 2024;82–91.

Ryan M. Knight, Russ S. Kotwal, Charles H. Moore

#### Preparing Future Military Medical Officers to Conduct Emergency Fresh Whole Blood Transfusions in Austere Environments: A Novel Training Curriculum

*Mil Med.* 2024;189(9-10):e2192–e2199.

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Kevin J. Matthews, Samuel Walther, Zachery L. Brown, Joshua P. Cuestas, Jonathan T. Shumaker, Durwood W. Moore, Rebekah Cole

**Introduction:** Providing resilient Damage Control Resuscitation capabilities as close to the point of injury as possible is paramount to reducing mortality and improving patient outcomes for our nation's warfighters. Emergency Fresh Whole Blood Transfusions (EFWBT) play a critical role in supporting this capability, especially in future large-scale combat operations against peer adversaries with expected large patient volumes, restrictive operating environments, and unreliable logistical supply lines. Although there are service-specific training programs for whole blood transfusion, there is currently no dedicated EFWBT training for future military medical officers. To address this gap, we developed, implemented, and evaluated a training program to enhance EFWBT proficiency in third-year military medical students at the F. Edward Hebert School of Medicine at the USU.

**Materials and methods:** After reviewing both the 75th Ranger Regiment Ranger O-Low Titer program and the Marine Corps' Valkyrie program, along with the relevant Joint Trauma System Clinical Practice Guidelines, we created a streamlined and abbreviated training curriculum. The training consisted of both online preparatory materials as well as a 2-hour in-person training that included didactic and experiential learning components. Participants were 165 active duty third-year medical students at USU. Participants were assessed using a pre- and post-assessment self-reported questionnaire on their confidence in the practical application and administrative oversight requirements of an EFWBT program. Participants' performance was also assessed using a pre/post knowledge assessment consisting of 10 multiple choice questions identified as critical to understanding of the academic principles of EFWBT along with the baseline questionnaire.

**Results:** Differences in the mean scores of the pre- and post-assessment self-reported questionnaire (increased from 2.32 to 3.95) were statistically significant ( $P < .001$ ). Similarly, there was a statistically significant improvement in student

test scores, with the mean score increasing by approximately 3 points or 30%. There was no significant difference in student confidence assessment or test scores based on branch of service. Students who had previously deployed did not show a statistically significant difference in scores compared to students who had not previously deployed.

**Conclusions:** Our results suggest that the implementation of streamlined EFWBT training into the undergraduate medical education of future military medical officers offers an efficient way to improve their baseline proficiency in EFWBTs. Future research is needed to assess the impact of this training on real-world applications in forward-deployed environments.

**A Review of 75th Ranger Regiment Battle-Injured Fatalities Incurred During Combat Operations From 2001 to 2021**  
*Mil Med.* 2024;189(7-8):1728–1737.

doi:10.1093/milmed/usad331

Charles H. Moore, Russ S. Kotwal, Jeffrey T. Howard, Montane B. Silverman, Jennifer M. Gurney, Andrew J. Rohrer, Ryan M. Knight

**Introduction:** The 75th Ranger Regiment is an elite U.S. military special operations unit that conducted over 20 years of sustained combat operations. The Regiment has a history of providing novel and cutting-edge prehospital trauma care, advancing and translating medical initiatives, and documenting and reporting casualty care performance improvement efforts.

**Materials and methods:** A retrospective case fatality rate (CFR) review, mortality review, and descriptive analysis of fatalities were conducted for battle-injured personnel assigned or attached to the 75th Ranger Regiment from 2001 to 2021 during combat operations primarily in Afghanistan and Iraq. Fatalities were evaluated for population characteristics, cause of death, mechanism of death, injury severity, injury survivability, and death preventability.

**Results:** A total of 813 battle injury casualties, including 62 fatalities, were incurred over 20 years and 1 month of continuous combat operations. The Regiment maintained a zero rate of prehospital preventable combat death. Additionally, no fatalities had a mechanism of death because of isolated extremity hemorrhage, tension pneumothorax, or airway obstruction. When comparing the CFR of the Regiment to the U.S. military population as a whole, the Regiment had a significantly greater reduction in the cumulative CFR as measured by the difference in average annual percentage change.

**Conclusions:** Documentation and analysis of casualties and care, mortality and casualty reviews, and other performance improvement efforts can guide combatant commanders, medical directors, and fighting forces to reduce preventable combat deaths and the CFR. Early hemorrhage control, blood product resuscitation, and other lifesaving interventions should be established and maintained as a standard prehospital practice to mitigate fatalities with potentially survivable injuries.

**The Association of Calcium Derangements With 24-Hour Outcomes in the Deployed Combat Setting**  
*Mil Med.* 2025;190(3-4):e498–e503.

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Matthew M. Nguyen, Melissa L. Givens, Andrew D. Fisher, Julie A. Rizzo, Ricky M Ditzel Jr., Maxwell A. Braverman, Michael D. April, Steven G. Schauer

**Introduction:** Calcium derangements remain poorly characterized in the combat trauma population. We describe the incidence of emergency department (ED) calcium derangements, associated physiologic derangements, and 24-hour mortality from the deployed combat setting.

**Materials and methods:** We analyzed adult casualties from 2007 to 2023 from the DoD Trauma Registry for U.S. military, U.S. contractor, and coalition casualties that had at least 1 ionized calcium value documented in the ED at a Role 2 or Role 3 military treatment facility. We constructed a series of multivariable logistic regression models to test for the association of hypocalcemia and hypercalcemia with physiological derangements, blood product consumption, and survival. Vital signs and other laboratory studies were based on the concurrent ED encounter.

**Results:** There were 941 casualties that met inclusion for this analysis with 26% (245) having at least 1 calcium derangement. Among those, 22% (211) had at least 1 episode of hypocalcemia and 5% (43) had at least 1 episode of hypercalcemia in the ED. The vast majority (97%, 917) received calcium at least once. Median composite injury severity scores were lower among those with no calcium derangement (8 versus 17,  $P < .001$ ). Survival was higher during the total hospitalization (98% versus 93%) among those with calcium derangements but similar at 24 hours (99% versus 98%,  $P = .059$ ). After adjusting for confounder, any hypocalcemic measurement was associated with an elevated international normalized ratio (odds ratio 1.94, 95% CI 1.19–3.16), acidosis (1.66, 1.17–2.37), tachycardia (2.11, 1.42–3.15), hypotension (1.92, 1.09–3.38), depressed Glasgow coma scale (3.20, 2.13–4.81), elevated shock index (2.19, 1.45–3.31), submassive transfusion (3.97, 2.60–6.05), massive transfusion (4.22, 2.66–6.70), supermassive transfusion (3.65, 2.07–6.43), and all hospital stay mortality (2.30, 1.00–5.29). Comparatively, any hypercalcemic measurement was associated with acidosis (2.96, 1.39–6.32), depressed Glasgow coma scale (4.28, 1.81–10.13), submassive transfusion (3.40, 1.37–8.43), massive transfusion (6.25, 2.63–14.83), and supermassive transfusion (13.00, 5.47–30.85).

**Conclusions:** Both hypocalcemia and hypercalcemia in the ED were associated with physiological derangements and blood product use, with a greater extent observed in those with hypocalcemia compared to those with hypercalcemia. Prospective studies are underway to better explain and validate these findings.

**Life Over Limb: Why Not Both? Revisiting Tourniquet Practices Based on Lessons Learned from the War in Ukraine**

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Jessica L. Patterson, Robert T. Bryan, Michael Turconi, Andrea Leiner, Timothy P. Plackett, Lori L. Rhodes, Luke Sciulli, Stephen Donnelly, Christopher W. Reynolds, Joseph Leanza, Andrew D. Fisher, Taras Kushnir, Valerii Artemenko, Kevin R. Ward, John B. Holcomb, Florian F. Schmitzberger

The use of tourniquets for life-threatening limb hemorrhage is standard of care in military and civilian medicine. The United States (U.S.) Department of Defense (DoD) Committee on Tactical Combat Casualty Care (CoTCCC) guidelines, as part of the Joint Trauma System, support the application of tourniquets within a structured system reliant on highly

trained medics and expeditious evacuation. Current practices by entities such as the DoD and North Atlantic Treaty Organization (NATO) are supported by evidence collected in counter-insurgency operations and other conflicts in which transport times to care rarely went beyond one hour, and casualty rates and tactical situations rarely exceeded capabilities. Tourniquets cause complications when misused or utilized for prolonged durations, and in near-peer or peer-peer conflicts, contested airspace and the impact of high-attrition warfare may increase time to definitive care and limit training resources. We present a series of cases from the war in Ukraine that suggest tourniquet practices are contributing to complications such as limb amputation, overall morbidity and mortality, and increased burden on the medical system. We discuss factors that contribute to this phenomenon and propose interventions for use in current and future similar contexts, with the ultimate goal of reducing morbidity and mortality.

### Hypothermia and the Global War on Terror: 18 Years of Minimal Progress

*Mil Med.* 2024;189(Suppl 3):190–195.  
doi:10.1093/milmed/usac072

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**Introduction:** The association between hypothermia, coagulopathy, and acidosis in trauma is well described. Hypothermia mitigation starts in the prehospital setting; however, it is often a secondary focus after other life-saving interventions. The deployed environment further compounds the problem due to prolonged evacuation times in rotary wing aircraft, resource limitations, and competing priorities. This analysis evaluates hypothermia in combat casualties and the relationship to resuscitation strategy with blood products.

**Methods:** Using the data from the Department of Defense Joint Trauma Registry from 2003 to 2021, a retrospective analysis was conducted on adult trauma patients. Inclusion criteria was arrival at the first military treatment facility (MTF) hypothermic (<95°F). Study variables included: mortality, year, demographics, battle vs non-battle injury, mechanism, theater of operation, vitals, and labs. Subgroup analysis was performed on severely injured (15 < ISS < 75) hypothermic trauma patients resuscitated with whole blood (WB) vs only component therapy.

**Results:** Of the 69,364 patients included, 908 (1.3%) arrived hypothermic; the vast majority of whom (N = 847, 93.3%) arrived mildly hypothermic (90–94.9°F). Overall mortality rate was 14.8%. Rates of hypothermia varied by year from 0.7% in 2003 to 3.9% in 2014 (P < 0.005). On subgroup analysis, mortality rates were similar between patients resuscitated with WB vs only component therapy; though base deficit values were higher in the WB cohort (-10 vs -6, P < 0.001).

**Conclusion:** Despite nearly 20 years of combat operations, hypothermia continues to be a challenge in military trauma and is associated with a high mortality rate. Mortality was similar between hypothermic trauma patients resuscitated with WB vs component therapy, despite greater physiologic derangements on arrival in patients who received WB. As the military has the potential to conduct missions in environments where the risk of hypothermia is high, further research into hypothermia mitigation techniques and resuscitation strategies in the deployed setting is warranted.

### Committee on Tactical Combat Casualty Care (CoTCCC) Position Statement on Prolonged Casualty Care (PCC): 01 May 2024

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Michael A. Remley, Dan Mosley, Sean Keenan, Travis G. Deaton, Harold R. Montgomery, Russ S. Kotwal, George A. Barbee, Lanny F. Littlejohn, Justin Wilson, Curtis Hall, Paul E. Loos, John B. Holcomb, Jennifer M. Gurney

### Casualty Evacuation in Arctic and Extreme Cold Environments: A Paradigm Shift for Traumatic Hypothermia Management in Tactical Combat Casualty Care

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In Arctic or extreme cold environments of Alaska, trauma care is complicated by large expanses of geography and lack of forward-positioned resources. This paper presents four hypothetical vignettes highlighting austere cold medical priorities: (1) traumatic hypothermia management as part of Tactical Combat Casualty Care (TCCC) is clinically and tactically important and hypothermia needs to be reprioritized in the MARCH algorithm to MhARCH; (2) at present it is unknown which TCCC recommended medical equipment/supplies will function as designed in the extreme cold; (3) ensuring advanced resuscitative care measures are available serves as a temporal bridge until casualties can receive damage control resuscitation (DCR); and (4) current systems for managing traumatic hypothermia in TCCC and casualty evacuation (CASEVAC) are insufficient. In conclusion, numerous assessments recognise the DoD's current solutions for employing medical forces in Arctic operations are not optimally postured to save lives. There should be a joint standard for fielding an arctic supplement to current medical equipment sets. A new way of thinking in terms of an "ecosystem" approach of immediate casualty protection and movement in CASEVAC doctrine is needed to optimise these "Golden Minutes."

### Limitations of Triage in Military Mass Casualty Response: A Case Series

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**Introduction:** Mass casualty events (MASCALs) in the combat environment, which involve large numbers of casualties that overwhelm immediately available resources, are fundamentally chaotic and dynamic and inherently dangerous. Formal triage systems use diagnostic algorithms, colored markers, and four or more named categories. We hypothesized that formal triage systems are inadequately trained and practiced and too complex to successfully implement in true MASCAL events. This retrospective analysis evaluates the real-world application of triage systems in prehospital military MASCALs and other aspects of MASCAL management.



**Methods:** We surveyed Special Operations Forces (SOF) medics known to us who have participated in military prehospital MASCALs and analyzed them. Aggregated data describing the scope of the incidents, the use of formal triage algorithms and colored markers, the number of categories, and the interventions on scene were analyzed using descriptive statistics, and lessons learned were consolidated.

**Results:** From 1996 to 2022 we identified 29 MASCALs that were managed by military medics in the prehospital setting. There was a median of three providers (range 1-85) and 15 casualties (range 6-519) per event. Four or more formal triage categories were used in only one event. Colored markers and formal algorithms were not used. Life-saving interventions were performed in 27 of 29 (93%) missions and blood transfusions were performed in four (17%) MASCALs. The top lessons learned were: 1) security and accountability are cornerstones of MASCAL management; 2) casualty movement is a priority; 3) intuitive triage categories are the default; 4) life-saving interventions are performed as time and tactics permit.

**Conclusion:** Formal triage systems requiring the use of diagnostic algorithms, colored tags, and four or five categories are seldom implemented in real-world military prehospital MASCAL management. The training of field triage should be simplified and pragmatic, as exemplified by these instances.

#### Maritime Applications of Prolonged Casualty Care: A Series Introduction

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The current United States Navy and North Atlantic Treaty Organization (NATO) maritime strategy is coalescing around the concept of Distributed Maritime Operations (DMOs) to prepare for future large-scale combat operations with peer or near-peer competitors. As a result, individual components of naval forces will be more geographically dispersed and operating at a significant time and distance from higher levels of medical care. We developed a series of educational scenarios informed by real-world events to enhance the ability of Role 1 medical caregivers to apply the principles of Prolonged Casualty Care during current routine, crisis, and contingency DMOs.

#### Needlessly Treated: Evaluation of Prehospital Needle Thoracostomy

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**Background:** Needle thoracostomy is a potentially life-saving intervention for tension pneumothorax but may be overused, potentially leading to unnecessary morbidity.

**Objective:** To review prehospital needle thoracostomy indications, effectiveness, and adverse outcomes.

**Methods:** A retrospective cohort study was conducted based on registry data for a United States Midwestern Level I trauma center for a 7.5-year period (January 2015 to May 2022). Included were patients who received prehospital needle thoracostomy and trauma activation before hospital arrival. The primary outcomes were correct indications and improvement in vital signs. Secondary outcomes were the need for chest tubes, correct needle placement, complications, and survival.

**Results:** A total of  $n = 67$  patients were reviewed, of which  $n = 63$  (94%) received a prehospital thoracostomy. Of the 63 prehospital thoracostomies, 54 (86%) survived to arrival. Of these 54, 44 ( $n = 81\%$ ) had documented reduced/absent breath sounds, 15 (28%) hypotension, and 19 (35%) with difficulty breathing/ventilating. Only four patients met all three prehospital trauma life support criteria: hypotension, difficulty ventilating, and absent breath sounds. There were no significant changes in prehospital vitals before and after receiving needle thoracostomy. In patients receiving imaging ( $n = 54$ ), there was evidence of 15 (28%) lung lacerations, 6 (11%) of which had a pneumothorax and 3 (5%) near misses of important structures. Review of needle catheters visible on computer tomography imaging found 11 outside the chest and 1 in the abdominal cavity.

**Conclusion:** The study presents evidence of potential needle thoracostomy overuse and morbidity. Adherence to specific guidelines for needle decompression is needed.

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