Tactical Combat Casualty Care

&

En Route Combat Casualty Care

2023 Journal Watch

Journal Article Abstracts

Apr 2023- Jun 2023

A quarterly literature review of topics related to Tactical Combat Casualty Care (TCCC) and En Route Combat Casualty Care (ERCCC) from the months of Dec 2019 through Mar 2020.

Posting of articles does not imply agreement or disagreement with the contents nor constitute a change in TCCC or ERCCC guidelines, practices, or training. Links are provided to respective publications for further reading and research. Additional log-in requirements may be required at various websites. 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.

The CoTCCC is the branch of the JTS focused on the standard of care for prehospital battlefield medicine. The CoERCCC is the branch of the JTS focused on the standard of care for en route care medicine 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) providing clinical practice guidelines and performance improvement for all levels of military trauma care.

Antibiotic Usage in the Management of Wartime Casualties

Justin Lee Anderson, Shane Kronstedt, Matthew A Bergens, Jay Johannigman

J Spec Oper Med. 2023 Mar 15;23(1):103-106.

No abstract available

Adherence to a Balanced Approach to Massive Transfusion in Combat Casualties

Michael D April, Andrew D Fisher, Ronnie Hill, Julie A Rizzo, Kennedy Mdaki, James Bynum, Steven G Schauer

Mil Med. 2023 Mar 20;188(3-4):e524-e530.

Background: Hemorrhage is the most common cause of potentially preventable death on the battlefield. Balanced resuscitation with plasma, platelets, and packed red blood cells (PRBCs) in a 1:1:1 ratio, if whole blood (WB) is not available, is associated with optimal outcomes among patients with hemorrhage. We describe the use of balanced resuscitation among combat casualties undergoing massive transfusion.

Materials and methods: We conducted a secondary analysis of data from the Department of Defense Trauma Registry (DODTR) spanning encounters from January 1, 2007, to March 17, 2020. We included all casualties who received at least 10 units of either PRBCs or WB. We categorized casualties as recipients of plasma-balanced resuscitation if the ratio of plasma to PRBC units was 0.8 or greater; similarly, we defined platelet-balanced resuscitation as a ratio of platelets to PRBC units of 0.8 or greater. We portrayed these populations using descriptive statistics and compared characteristics between non-balanced and balanced resuscitation recipients for both plasma and platelets.

Results: We identified 28,950 encounters in the DODTR with documentation of prehospital activity. Massive transfusions occurred for 2,414 (8.3%) casualties, among whom 1,593 (66.0%) received a plasma-balanced resuscitation and 1,248 (51.7%) received a platelet-balanced resuscitation. During the study period, 962 (39.8%) of these patients received a fully balanced resuscitation with regard to both the plasma:PRBC and platelet:PRBC ratios. The remaining casualties did not undergo a balanced resuscitation.

Conclusions: While a majority of massive transfusion recipients received a plasma-balanced and/or platelet-balanced resuscitation, fewer patients received a platelet-balanced resuscitation. These findings suggest that more emphasis in training and supply may be necessary to optimize blood product resuscitation ratios.

Association Between Profound Shock Signs and Peripheral Intravenous Access Success Rates in Trauma Patients in the Prehospital Scenario: A Retrospective Study

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Anesth Analg. 2023 May 1;136(5):934-940.

Background: Hemorrhage is the leading cause of preventable death in trauma patients, and establishment of intravenous (IV) access is essential for volume resuscitation, a key component in the treatment of hemorrhagic shock. IV access among patients in shock is generally considered more challenging, although data to support this notion are lacking.

Methods: In this retrospective registry-based study, data were collected from the Israeli Defense Forces Trauma Registry (IDF-TR) regarding all prehospital trauma patients treated by IDF medical forces between January 2020 and April 2022, for whom IV access was attempted. Patients younger than 16 years, nonurgent patients, and patients with no detectable heart rate or blood pressure were excluded. Profound shock was defined as a heart rate >130 or a systolic blood pressure <90 mm Hg, and comparisons were made between patients with profound shock and those not exhibiting such signs. The primary outcome was the number of attempts required for first IV access success, which was regarded as an ordinal categorical variable: 1, 2, 3 and higher and ultimate failure. A multivariable ordinal logistic regression was performed to adjust for potential confounders. Patients' sex, age, mechanism of injury and best consciousness level, as well as type of event (military/nonmilitary), and the presence of multiple patients were included in the ordinal logistic regression multivariable analysis model based on previous publications.

Results: Five hundred thirty-seven patients were included, 15.7% of whom were recorded as having signs of profound shock. Peripheral IV access establishment first attempt success rates were higher in the nonshock group, and there was a lower rate of unsuccessful attempts in this group (80.8% vs 67.8% for the first attempt, 9.4% vs 16.7% for the second attempt, 3.8% vs 5.6% for the third and further attempts, and 6% vs 10% unsuccessful attempts, P = .04). In the univariable analysis, profound shock was associated with requirement for an increased number of IV attempts (odds ratio [OR], 1.94; confidence interval [CI], 1.17-3.15). The ordinal logistic regression multivariable analysis demonstrated that profound shock was associated with worse results regarding primary outcome (adjusted odds ratio [AOR], 1.84; CI, 1.07-3.10).

Conclusions: The presence of profound shock in trauma patients in the prehospital scenario is associated with an increased number of attempts required for IV access establishment.

Supraglottic airway devices are associated with asphyxial physiology after prolonged CPR in patients with refractory Out-of-Hospital cardiac arrest presenting for extracorporeal cardiopulmonary resuscitation

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Resuscitation. 2023 May:186:109769.

Background: Multiple randomized clinical trials have compared specific airway management strategies during ACLS with conflicting results. However, patients with refractory cardiac arrest died in almost all cases without the availability of extracorporeal cardiopulmonary resuscitation (ECPR). Our aim was to determine if endotracheal intubation (ETI) was associated with improved outcomes compared to supraglottic airways (SGA) in patients with refractory cardiac arrest presenting for ECPR.

Methods: We retrospectively studied 420 consecutive adult patients with refractory out-of-hospital cardiac arrest due to shockable presenting rhythms presenting to the University of Minnesota ECPR program. We compared outcomes between patients receiving ETI (n = 179) and SGA (n = 204). The primary outcome was the pre-cannulation arterial PaO2 upon arrival to the ECMO cannulation center. Secondary outcomes included neurologically favorable survival to hospital discharge and eligibility for VA-ECMO based upon resuscitation continuation criteria applied upon arrival to the ECMO cannulation center.

Results: Patients receiving ETI had significantly higher median PaO2 (71 vs. 58 mmHg, $p = 0.001$), lower median PaCO2 (55 vs. 75 mmHg, $p < 0.001$), and higher median pH (7.03 vs. 6.93, $p < 0.001$) compared to those receiving SGA. Patients receiving ETI were also significantly more likely to meet VA-ECMO eligibility criteria (85% vs. 74%, $p = 0.008$). Of patients eligible for VA-ECMO, patients receiving ETI had significantly higher neurologically favorable survival compared to SGA (42% vs. 29%, $p = 0.02$).

Conclusions: ETI was associated with improved oxygenation and ventilation after prolonged CPR. This resulted in increased rate of candidacy for ECPR and increased neurologically favorable survival to discharge with ETI compared to SGA.

Injury trends aboard US Navy vessels: A 50-year analysis of mishaps at sea

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J Trauma Acute Care Surg. 2023 Aug 1;95(2S Suppl 1):S41-S49. Epub 2023 May 18.

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.

Prehospital Hemorrhage Control and Treatment by Clinicians: A Joint Position Statement

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Prehosp Emerg Care. 2023;27(5):544-551.

Abstract

Exsanguination remains the leading cause of preventable death among victims of trauma. For adult and pediatric trauma patients in the prehospital phase of care, methods to control hemorrhage and hemostatic resuscitation are described in this joint consensus opinion by the American College of Surgeons Committee on Trauma, the American College of Emergency Physicians, and the National Association of EMS Physicians.

Association between prehospital end-tidal carbon dioxide levels and mortality in patients with suspected severe traumatic brain injury

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Intensive Care Med. 2023 May;49(5):491-504.

Purpose: Severe traumatic brain injury is a leading cause of mortality and morbidity, and these patients are frequently intubated in the prehospital setting. Cerebral perfusion and intracranial pressure are influenced by the arterial partial pressure of CO2 and derangements might induce further brain damage. We investigated which lower and upper limits of prehospital end-tidal CO2 levels are associated with increased mortality in patients with severe traumatic brain injury.

Methods: The BRAIN-PROTECT study is an observational multicenter study. Patients with severe traumatic brain injury, treated by Dutch Helicopter Emergency Medical Services between February 2012 and December 2017, were included. Follow-up continued for 1 year after inclusion. End-tidal CO2 levels were measured during prehospital care and their association with 30-day mortality was analyzed with multivariable logistic regression.

Results: A total of 1776 patients were eligible for analysis. An L-shaped association between end-tidal CO2 levels and 30-day mortality was observed ($p = 0.01$), with a sharp increase in mortality with values below 35 mmHg. End-tidal CO2 values between 35 and 45 mmHg were associated with better survival rates compared to < 35 mmHg. No association between hypercapnia and mortality was observed. The odds ratio for the association between hypocapnia (< 35 mmHg) and mortality was 1.89 (95% CI 1.53-2.34, $p < 0.001$) and for hypercapnia (≥ 45 mmHg) 0.83 (0.62-1.11, $p = 0.212$).

Conclusion: A safe zone of 35-45 mmHg for end-tidal CO2 guidance seems reasonable during prehospital care. Particularly, end-tidal partial pressures of less than 35 mmHg were associated with a significantly increased mortality.

Prevalence of Trauma-Induced Hypocalcemia in the Prehospital Setting

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J Spec Oper Med. 2023 Jun 23;23(2):44-48.

Background: Recent data published by the Special Operations community suggest the Lethal Triad of Trauma should be changed to the Lethal Diamond, to include coagulopathy, acidosis, hypothermia, and hypocalcemia. The purpose of this study is to determine the prevalence of trauma-induced hypocalcemia in level I and II trauma patients.

Methods: This is a retrospective cohort study conducted at a level I trauma center and Special Operations Combat Medic (SOCM) training site. Adult patients were identified via trauma services registry from September 2021 to April 2022. Patients who received blood products prior to emergency department (ED) arrival were excluded from the study. Ionized calcium levels were utilized in this study.

Results: Of the 408 patients screened, 370 were included in the final analysis of this cohort. Hypocalcemia was noted in 189 (51%) patients, with severe hypocalcemia identified in two (<1%) patients. Thirty-two (11.2%) patients had elevated international normalized ratio (INR), 34 (23%) patients had pH <7.36, 21 (8%) patients had elevated lactic acid, and 9 (2.5%) patients had a temperature of <35°C.

Conclusion: Hypocalcemia was prevalent in half of the trauma patients in this cohort. The administration of a calcium supplement empirically in trauma patients from the prehospital environment and prior to blood transfusion is not recommended until further data prove it beneficial.

The impact of prehospital whole blood on hemorrhaging trauma patients: A multi-center retrospective study

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J Trauma Acute Care Surg. 2023 Aug 1;95(2):191-196.

Background: Whole blood (WB) use has become increasingly common in trauma centers across the United States for both in-hospital and prehospital resuscitation. We hypothesize that prehospital WB (pWB) use in trauma patients with suspected hemorrhage will result in improved hemodynamic status and reduced in-hospital blood product requirements.

Methods: The institutional trauma registries of two academic level I trauma centers were queried for all patients from 2015-2019 who underwent transfusion upon arrival to the trauma bay. Patients who were dead on arrival or had isolated head injuries were excluded. Demographics, injury and shock characteristics, transfusion requirements, including massive transfusion protocol (MTP) (>10 U in 24 hours) and rapid transfusion (CAT3+) and outcomes were compared between pWB and non-pWB patients. Significantly different demographic, injury characteristics and pWB were included in univariate followed by stepwise logistic regression analysis to determine the relationship with shock index (SI). Our primary objective was to determine the relationship between pWB and improved hemodynamics or reduction in blood product utilization.

Results: A total of 171 pWB and 1391 non-pWB patients met inclusion criteria. Prehospital WB patients had a lower median Injury Severity Score (17 vs. 21, $p < 0.001$) but higher prehospital SI showing greater physiologic disarray. Prehospital WB was associated with improvement in SI (-0.04 vs. 0.05, $p = 0.002$). Mortality and (LOS) were similar. Prehospital WB patients received fewer packed red blood cells, fresh frozen plasma, and platelets units across their LOS but total units and volumes were similar. Prehospital WB patients had fewer MTPs (22.6% vs. 32.4%, $p = 0.01$) despite a similar requirement of CAT3+ transfusion upon arrival.

Conclusion: Prehospital WB administration is associated with a greater improvement in SI and a reduction in MTP. This study is limited by its lack of power to detect a mortality difference. Prospective randomized controlled trials will be required to determine the true impact of pWB on trauma patients.

Pressure Injury Mitigation in Prolonged Care: A Randomized Noninferiority and Superiority Trial

Elizabeth Bridges, JoAnne D Whitney, Robert Burr, Ernie Tolentino

Mil Med. 2023 Apr 22:usad121. Online ahead of print.

Introduction: Combat casualties are at increased risk for pressure injuries (PIs) during prolonged casualty care. There is limited research on operational PI risk mitigation strategies. The purpose of this study was to (1) compare a prototype mattress (AirSupport) designed for operational conditions versus the foldable Talon litter and Warrior Evacuation Litter Pad (WELP) on PI risk factors and (2) determine whether the Talon + AirSupport pad was noninferior and superior to the Talon + WELP on skin interface pressure.

Materials and methods: Healthy adults (N = 85; 20 men and 65 women), aged 18 to 55 years, were stratified based on body fat percentage and randomized into three groups: Talon (n = 15), Talon + AirSupport (n = 35), and Talon + WELP (n = 35). The participants were asked to lie in a supine position for 1 hour. The outcomes included skin interface pressure (body surface areas: Sacrum, buttocks, occiput, and heels), sacral and buttock skin temperature and moisture, and discomfort and pressure. The study was approved by the University of Washington Institutional Review Board.

Results: Aim 1: The Talon had significantly higher peak skin interface pressure versus the AirSupport and WELP on the sacrum, buttocks, occiput, and heels. Skin temperature increase over the 1-hour loaded period was significantly lower on Talon versus AirSupport or WELP, reflecting a lower temperature-induced ischemic load. There was no significant difference in skin moisture changes or discomfort between the surfaces. Aim 2: The upper confidence limits for the difference in skin interface pressure (all body surface areas) for AirSupport versus WELP were below 25 mm Hg, establishing noninferiority of the AirSupport to the WELP. AirSupport was also superior to WELP for the peak interface pressure on the sacrum, occiput, and heels but not on the buttocks. Skin temperature changes (sacrum or buttocks) were not significantly different between the AirSupport and WELP.

Conclusions: The Talon litter presents a PI risk because of increased skin interface pressure, and hence, immediate action is warranted. The decreased PI risk associated with the lower skin interface pressures on the AirSupport and WELP was offset by the higher skin temperature, which may add the equivalent of 20 to 30 mm Hg pressure to the ischemic burden. Thus, any pressure redistribution intervention must be evaluated with a consideration for skin interface pressure, temperature, and moisture. Data from this study were applied to a predictive model for skin damage. Under operational conditions where resources and the environment may limit patient repositioning, it would be expected that casualties would suffer skin damage within 2 to 5 hours, with the occiput as the highest risk area. The severity of predicted skin damage is lowest on the AirSupport, which is consistent with the noninferiority and superiority of the AirSupport mattress compared to the WELP and Talon. Operational utility: The AirSupport and WELP, which were both superior to the Talon, are operationally feasible solutions to mitigate PI risk. The smaller size of the Talon (2.7 kgs compressible) versus the WELP (5 kgs noncompressible) may make them appropriate for different levels of the operational setting.

Nonsurgical management of major hemorrhage

Jeannie Callum, Christopher C D Evans, Alan Barkun, Keyvan Karkouti

CMAJ. 2023 Jun 5;195(22):E773-E781.

Empiric tranexamic acid use provides no benefit in urgent orthopedic surgery following injury

Trauma Surg Acute Care Open. 2023 Mar 10;8(1):e001054.

Bryan Carr, Shi-Wen Li, Jamel G Hill, Cyrus Feizpour, Ben L Zarzaur, Stephanie Savage

Background: Orthopedic literature has demonstrated a significant decrease in postoperative transfusion requirements when tranexamic acid (TXA) was given during elective joint arthroplasty. The purpose of this study was to evaluate the empiric use of TXA in semi-urgent orthopedic procedures following injury. We hypothesized that TXA would be associated with increased rates of venous thromboembolic events (VTE) and have no effect on transfusion requirements.

Methods: Patients who empirically received TXA during a semi-urgent orthopedic surgery following injury (TXA+) were matched using propensity scoring to historical controls (CONTROL) who did not receive TXA. Outcomes included VTE within 6 months of injury and packed red blood cell utilization. Multivariable logistic regression and generalized linear modeling were used to determine odds of VTE and transfusion.

Results: 200 patients were included in each group. There was no difference in mortality between groups. TXA+ patients did not have an increase in VTE events (OR 0.680, 95% CI 0.206 to 2.248). TXA+ patients had a significantly higher odds of being transfused during their hospital stay (OR 2.175, 95% CI 1.246 to 3.797) and during the index surgery (increased 0.95 units (SD 0.16), $p<0.0001$). Overall transfusion was also significantly higher in the TXA+ group ($p=0.0021$).

Conclusion: Empiric use of TXA in semi-urgent orthopedic surgeries did not increase the odds of VTE. Despite the elective literature, TXA administration did not associate with less transfusion requirements. A properly powered, prospective, randomized trial should be designed to elucidate the risks and benefits associated with TXA use in this setting.

Where There's a War, There's a Way: A Brief Report on Tactical Combat Casualty Care Training in a Multinational Environment

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J Spec Oper Med. 2023 Mar 15;23(1):130-133.

Background: With most combat deaths occurring in prehospital settings, the US Armed Forces focuses on life-threatening conditions at or near the point of injury. Tactical Combat Casualty Care (TCCC) guidelines are required for all US Servicemembers. Multinational militaries lack this requirement, and international partner forces often have limited prehospital medical training.

Methods: From November 2019 to March 2020, military members assigned to the Role 2E at the Hamid Kazai International Airport (HKIA) North Atlantic Treaty Organization (NATO) base conducted multinational TCCC training. The standardized Joint Trauma System (JTS) TCCC curriculum consisted of two-day classroom instruction and situational training exercises. Competency was assessed through verbalized and demonstrated knowledge. After Action Reviews (AAR) were completed.

Results: Twelve multinational TCCC training courses trained 590 military Servicemembers and civilians from 10 countries, ranging from 16 to 62 participants (avg class size = 35). Portugal and Turkey represented the two largest participating nations with 219 and 133, respectively. Student feedback determined optimal group ratios for instruction. AARs were reviewed to categorize best practices.

Conclusion: Multinational TCCC standardization will save lives. Most nations lack TCCC training requirements. Thus, providing opportunities for standardized training for HKIA residents helped established a multinational baseline of medical interoperability. Utilizing this curriculum in multinational environments can replicate these results. International adoption of TCCC is dynamic and ongoing and should be promulgated to reduce preventable deaths.

Paramedic to trauma team verbal handover optimization - a complex interaction

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Can J Surg. 2023 May 24;66(3):E290-E297.

Background: Handover to the trauma team is crucial to trauma care. The emergency medical services (EMS) report must be concise, contain key details, and be time-limited. Effective handover is difficult, often occurring between unfamiliar teams, in chaotic environments, and without standardization. We aimed to evaluate handover formats in comparison to ad-lib communication during trauma handover.

Methods: We conducted a single-blind randomized simulation trial evaluating 2 structured handover formats. Paramedics randomly assigned to ad-lib, ISOBAR (identify, situation, observations, background, agreed plan, and readback) or IMIST (identification, mechanism/medical complaint, injuries/ information about complaint, signs, treatments) handover formats underwent scenarios in an ambulance, then transfer to the trauma team. Assessment of handovers was completed by the trauma team and by experts using audiovisual recordings.

Results: Twenty-seven simulations were conducted, 9 for each handover format. Participant ratings of the usefulness of the IMIST and ISOBAR formats were 9/10 and 7.5/10, respectively ($p = 0.097$). Quality of the handover was deemed higher by team members when a statement of objective vital signs and a logical format was used. Handovers delivered with confidence, directed and summarized by a trauma team leader, before physical patient transfer, and without interruption were identified as having the highest quality. The type of format was not a significant contributor to handover; however, we identified a matrix of factors affecting the quality of trauma handover.

Conclusion: Our study shows agreement by prehospital and hospital personnel that a standardized handover tool is preferred. A brief confirmation of physiologic stability, including vital signs, limiting distractions, and team summarization improves handover effectiveness.

Low-dose ketamine or opioids combined with propofol for procedural sedation in the emergency department: a systematic review

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Eur J Emerg Med. 2023 Aug 1;30(4):244-251.

Abstract

Procedural sedation is routinely performed for procedures in the emergency department (ED). Propofol is a commonly used sedative, frequently combined with an opioid or low-dose ketamine as an analgesic. However, there is still controversy on the optimal combination of agents in current guidelines. The objective of this systematic review is to identify and present studies comparing low-dose ketamine to opioids when combined with propofol for procedural sedation in the ED and to describe the dosing regimen, observed efficacy, and side effects. For this systematic review, following the Preferred Reporting Items for Systematic Review and Meta-Analysis guidelines, EMBASE and PubMed databases were searched. Studies comparing propofol with opioids versus propofol with low-dose (es)ketamine in patients undergoing procedural sedation for procedures in the ED were included. Analyses were descriptive because of the high heterogeneity among included studies. The outcomes were dosing regimen, efficacy of analgesia, efficacy of sedation depth, efficacy of recovery and (adverse) events. We included four out of 2309 studies found in the literature search. Overall, the studies had a low risk of bias, but the Grading of Recommendations Assessment, Development, and Evaluation evidence profile was downgraded due to the imprecision and inconsistency of the studies. All studies compared low-dose ketamine with fentanyl. Dosing ranged from 0.3 to 1.0 mg/kg (ketamine), 1.0-1.5 µg/kg (fentanyl) and 0.4-1.0 mg/kg (propofol). The efficacy of analgesia was measured by two studies, one favoring the fentanyl group, and one favoring the ketamine group. The efficacy of sedation depth was measured by one study, with the fentanyl group having a deeper sedation score. Two studies showed shorter recovery time with low-dose ketamine. One study showed a higher incidence of cardio-respiratory clinical events and interventions in the fentanyl group. Two studies showed significant differences of overall sedation events in the fentanyl group. One study did not find any significant differences of the incidence of sedation events. This systematic review did not provide sufficient evidence that the combination of low-dose ketamine and propofol is associated with a shorter recovery time and fewer sedation events compared to the combination of opioids and propofol.

Time to early resuscitative intervention association with mortality in trauma patients at risk for hemorrhage

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J Trauma Acute Care Surg. 2023 Apr 1;94(4):504-512.

Background: Hemorrhage is the leading cause of preventable death after injury. Others have shown that delays in massive transfusion cooler arrival increase mortality, while prehospital blood product resuscitation can reduce mortality. Our objective was to evaluate if time to resuscitation initiation impacts mortality.

Methods: We combined data from the Prehospital Air Medical Plasma (PAMPer) trial in which patients received prehospital plasma or standard care and the Study of Tranexamic Acid during Air and ground Medical Prehospital transport (STAAMP) trial in which patients received prehospital tranexamic acid or placebo. We evaluated the time to early resuscitative intervention (TERI) as time from emergency medical services arrival to packed red blood cells, plasma, or tranexamic acid initiation in the field or within 90 minutes of trauma center arrival. For patients not receiving an early resuscitative intervention, the TERI was calculated based on trauma center arrival as earliest opportunity to receive a resuscitative intervention and were propensity matched to those that did to account for selection bias. Mixed-effects logistic regression assessed the association of 30-day and 24-hour mortality with TERI adjusting for confounders. We also evaluated a subgroup of only patients receiving an early resuscitative intervention as defined above.

Results: Among the 1,504 propensity-matched patients, every 1-minute delay in TERI was associated with 2% increase in the odds of 30-day mortality (adjusted odds ratio [aOR], 1.020; 95% confidence interval [CI], 1.006-1.033; $p < 0.01$) and 1.5% increase in odds of 24-hour mortality (aOR, 1.015; 95% CI, 1.001-1.029; $p = 0.03$). Among the 799 patients receiving an early resuscitative intervention, every 1-minute increase in TERI was associated with a 2% increase in the odds of 30-day mortality (aOR, 1.021; 95% CI, 1.005-1.038; $p = 0.01$) and 24-hour mortality (aOR, 1.023; 95% CI, 1.005-1.042; $p = 0.01$).

Conclusion: Time to early resuscitative intervention is associated with morality in trauma patients with hemorrhagic shock. Bleeding patients need resuscitation initiated early, whether at the trauma center in systems with short prehospital times or in the field when prehospital time is prolonged.

Scalpel cricothyrotomy versus punctured cricothyrotomy in the context of the CICO crisis. A systematic review and Meta-analysis

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Anaesth Crit Care Pain Med. 2023 Aug;42(4):101211.

Importance: The preferential use of a scalpel (SCT) or puncture techniques (PCT) for cricothyrotomy remains a controversial topic.

Objective: We performed a systematic review and meta-analysis comparing puncture cricothyrotomy with scalpel cricothyrotomy using overall success rate, first-time success rate, and time taken to perform the procedure as the primary outcome together with complications as a secondary outcome.

Evidence review: Pubmed databases, EMBASE databases, MEDLINE, Google Scholar, and Cochrane Central Register of Controlled Trials, from 1980 to October 2022.

Findings: A total of 32 studies were included in the systematic review and meta-analysis. It also showed that PCT was close to SCT in terms of overall success rate (82.2% vs. 82.6%, Odd Ratios OR = 0.91, [95%CI: 0.52-1.58], p = 0.74) as well as first-performance success rate (62.9% vs. 65.3%, OR = 0.52, [0.22-1.25], p = 0.15). PCT does not compare favorably with SCT in terms of required time for the procedure (the mean time required for PCT versus SCT incision in the intervention groups was 0.34 standard deviations higher (Mean Difference MD = 17.12, [3.37-30.87], p = 0.01) as well as complications (21.4% vs. 15.1%, Relative Risk RR = 1.49, [0.80-2.77], p = 0.21).

Conclusions and relevance: The results show that SCT has an advantage over PCT in terms of time required for the procedure, while there is no difference in overall success rate, first-time success rate after training, and complications. The superiority of SCT may be the result of fewer and more reliable procedural steps. However, the level of evidence is low (GRADE).

Combat Casualties Treated With Intranasal Ketamine for Prehospital Analgesia: A Case Series

Christophe Dubecq, Romain Montagnon, Gabriel Morand, Gael De Rocquigny, Ludovic Petit, Sebastien Peyrefitte, Olivier Dubourg, Pierre Pasquier, Pierre Mahe

J Spec Oper Med. 2023 Mar 15;23(1):84-87.

Abstract

Optimal pain management is challenging in Tactical Combat Casualty Care (TCCC), particularly in remote and austere settings. In these situations, appropriate treatment for prehospital analgesia can be limited or delayed due to the lack of intravenous access. Several guidelines suggest to implement intranasal (IN) analgesia in French Armed Forces for forward combat casualty care (Sauvetage au Combat), similar to the US TCCC. Four medical teams from the French Medical Military Service were deployed to the Middle East and Sahel from August 2017 to March 2019 and used IN ketamine for analgesia in 76 trauma patients, out of a total of 259 treated casualties. IN administration of ketamine 50mg appeared to be safe and effective, alone or in addition to other opioid analgesics. It also had minimal side effects and led to a reduction in the doses of ketamine and morphine used by the intravenous (IV) route. The French Military Medical Service supports current developments for personal devices delivering individual doses of IN ketamine. However, further studies are needed to analyze its efficacy and safety in combat zones.

Putting Medical Boots on the Ground: Lessons from the War in Ukraine and Applications for Future Conflict with Near-Peer Adversaries

Aaron Epstein, Robert Lim, Jay Johannigman, Charles J Fox, Kenji Inaba, Gary A Vercruysse, Richard W Thomas, Matthew J Martin, Gumeniuk Konstantyn, Steven D Schwaitzberg

J Am Coll Surg. 2023 Aug 1;237(2):364-373.

Abstract

In the past 20 years of the Global War on Terror, the US has seen substantial improvements in its system of medical delivery in combat. However, throughout that conflict, enemy forces did not have parity with the weaponry, capability, or personnel of the US and allied forces. War against countries like China and Russia, who are considered near-peer adversaries in terms of capabilities, will challenge battlefield medical care in many different ways. This article reviews the experience of a medical team, Global Surgical and Medical Support Group, that has been providing assistance, training, medical support, and surgical support to Ukraine since the Russian invasion began in February 2022. The team has extensive experience in medicine, surgery, austere environments, conflict zones, and building partner nation capacities. This article compares and contrasts the healthcare systems of this war against the systems used during the Global War on Terror. The lessons learned here could help the US anticipate challenges and successfully plan for the provision of medical care in a future conflict against an adversary with capabilities close to its own.

Prolonged Use of an Extraglottic Airway During Air Medical Transport From a Remote Alaskan Island

Benjamin Foorman, Richard B Utarnachitt, Kyle Danielson, Travis Brookie, Lee Henry, Andrew Latimer

Air Med J. 2022 Sep-Oct;41(5):491-493.

Abstract

Extraglottic devices (EGDs) are important tools for airway management in the prehospital and transport medicine environment. EGDs may be used as either a primary airway or rescue device depending on the provider skill level or patient circumstances. Although EGDs do not provide a definitive airway, they can facilitate oxygenation and ventilation in select patients. This is particularly important in the remote or austere environment when difficult airways are infrequently encountered. This case report details the prolonged use of an EGD during air medical transport from a rural Alaskan medical clinic to a large academic tertiary receiving facility, with the total time until definitive airway placement of approximately 9 hours. We review the prehospital coordination and evaluation, in-flight management, and successful transfer of care of the patient to the receiving tertiary center for definitive intervention.

Massive Trauma and Resuscitation Strategies

Carter M Galbraith, Brant M Wagener, Athanasios Chalkias, Shahla Siddiqui, David J Douin

Anesthesiol Clin. 2023 Mar;41(1):283-301.

Abstract

Massive trauma remains the leading cause of mortality among people aged younger than 45 years. In this review, we discuss the initial care and diagnosis of trauma patients followed by a comparison of resuscitation strategies. We discuss various strategies including use of whole blood and component therapy, examine viscoelastic techniques for management of coagulopathy, and consider the benefits and limitations of the resuscitation strategies and consider a series of questions that will be important for researchers to answer to provide the best and most cost-effective therapy for severely injured patients.

Association between three prehospital thoracic decompression techniques by physicians and complications: a retrospective, multicentre study in adults

Alan Garner, Elwyn Poynter, Ruth Parsell, Andrew Weatherall, Mary Morgan, Anna Lee

Eur J Trauma Emerg Surg. 2023 Feb;49(1):571-581.

Introduction: We sought to compare the complication rates of prehospital needle decompression, finger thoracostomy and three tube thoracostomy systems (Argyle, Frontline kits and endotracheal tubes) and to determine if finger thoracostomy is associated with shorter prehospital scene times compared with tube thoracostomy.

Methods: In this retrospective cohort study we abstracted data on adult trauma patients transported by three helicopter emergency medical services to five Major Trauma Service hospitals who underwent a prehospital thoracic decompression procedure over a 75-month period. Comparisons of complication rates for needle, finger and tube thoracostomy and between tube techniques were conducted. Multivariate models were constructed to determine the relative risk of complications and length of scene time by decompression technique.

Results: Two hundred and fifty-five patients underwent 383 decompression procedures. Fifty eight patients had one complication, and two patients had two complications. There was a weak association between decompression technique (finger vs tube) and adjusted risk of overall complication (RR 0.58, 95% CI: 0.33-1.03, P = 0.061). Recurrent tension physiology was more frequent in finger compared with tube thoracostomy (13.9 vs 3.2%, P < 0.001). Adjusted prolonged (80th percentile) scene time was not significantly shorter in patients undergoing finger vs tube thoracostomy (56 vs 63 min, P = 0.197), nor was the infection rate lower (2.7 vs 2.1%, P = 0.85).

Conclusions: There was no clear evidence for benefit associated with finger thoracostomy in reducing overall complication rates, infection rates or scene times, but the rate of recurrent tension physiology was significantly higher. Therefore, tube placement is recommended as soon as practicable after thoracic decompression.

Manual Pressure Points Technique for Massive Hemorrhage Control-A Prospective Human Volunteer Study

Regina Pikman Gavriely, Yotam Lior, Shaul Gelikas, Shiran Levy, Alon Ahimor, Elon Glassberg, Shachar Shapira, Avi Benov, Guy Avital

Prehosp Emerg Care. 2023;27(5):586-591.

Background: While commonly thought to be effective for management of limb and junctional hemorrhage, the manual pressure points technique was excluded from leading prehospital guidelines over a decade ago following the publication of a single human-volunteers study presenting unfavorable results. This work aimed to re-assess the efficacy and feasibility of the femoral and supraclavicular pressure points technique for temporary hemorrhage control distal to the pressure point.

Methods: A prospective, non-randomized, human volunteer, controlled environment study. In the study 35 healthy male combat medics (age 21.1 ± 1.3 years) received brief training after which they were requested to apply pressure in the femoral and supraclavicular points in attempts to stop regional blood flow, measured distally by Doppler ultrasound. Success rates in achieving flow cessation in under 2 minutes, time required for achievement of flow cessation, and cumulative flow cessation duration within a 3-minute follow-up after initial success were measured.

Results: For the supraclavicular point, success rates were 97.1% with a mean time to success of 12.5 (±20.9) seconds, lasting for 76.2% (±23.7) of the follow-up time. For the femoral point, success rates were 100% with a mean time to success of 5.5 (±4.3) seconds, lasting for 98.7% (±3.8) of the follow-up time.

Conclusions: Manual pressure on the femoral and supraclavicular points is an applicable and efficient method for temporary hemorrhage control distal to the pressure point. As such, with additional study, this method may be considered for re-introduction to prehospital care guidelines and training programs.

Evaluation of novel hemostatic agents in a coagulopathic swine model of junctional hemorrhage

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J Trauma Acute Care Surg. 2023 Aug 1;95(2S Suppl 1):S144-S151.

Background: Hemostatic dressings are used extensively in both military and civilian trauma to control lethal noncompressible hemorrhage. The ideal topical hemostatic agent would provide reliable hemostasis in patients with profound acidosis, coagulopathy, and shock. This study aimed to compare next-generation hemostatic agents against the current military standard in a translational swine model of vascular injury and coagulopathy.

Methods: Female Yorkshire swine were randomized to eight groups (total n = 63; control n = 14, per group n = 7) of hemostatic agents and included: QuikClot Combat Gauze (Teleflex, Morrisville, NC), which served as the control; BloodSTOP IX (LifeScience Plus, Mountain View, CA); Celox Rapid (Medtrade Product, Crewe, United Kingdom); ChitoSAM 100 (Sam Medical, Tualatin, OR); EVARREST Fibrin Sealant Patch (Ethicon, Raritan, NJ); TAC Wrapping Gauze (H&H Medical, Williamsburg, VA); ChitoGauze XR Pro (Tricol Biomedical, Portland, OR); and X-Stat 30 (RevMedX, Wilsonville, OR). Hemodilution via exchange transfusion of 6% hetastarch was performed to induce acidosis and coagulopathy. An arteriotomy was created, allowing 30 seconds of free bleeding followed by application of the hemostatic agent and compression via an external compression device. A total of three applications were allowed for continued/recurrent bleeding. All blood loss was collected, and hemostatic agents were weighed to calculate blood volume loss. Following a 180-minute observation period, angiography was completed to evaluate for technical complication and distal perfusion of the limb. Finally, the limb was ranged five times to assess for rebleeding and clot stability.

Results: All swine were confirmed coagulopathic with rotational thromboelastography and acidotic (pH 7.2 ± 0.02). BloodSTOP IX allowed a significant increase in blood loss and number of applications required to obtain hemostasis compared with all other groups. BloodSTOP IX demonstrated a decreased survival rate (29%, p = 0.02). All mortalities were directly attributed to exsanguination as a result of device failure. In surviving animals, there was no difference in extravasation. BloodSTOP IX had an increased rebleeding rate after ranging compared with QuikClot Combat Gauze (p = 0.007).

Conclusion: Most novel hemostatic agents demonstrated comparable efficacy compared with the currently military standard hemostatic dressing, CG.

Pre-hospital tranexamic acid administration in patients with a severe hemorrhage: an evaluation after the implementation of tranexamic acid administration in the Dutch pre-hospital protocol

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Eur J Trauma Emerg Surg. 2023 Apr 17. Online ahead of print.

Purpose: To evaluate the pre-hospital administration of tranexamic acid in ambulance-treated trauma patients with a severe hemorrhage after the implementation of tranexamic acid administration in the Dutch pre-hospital protocol.

Methods: All patients with a severe hemorrhage who were treated and conveyed by EMS professionals between January 2015, and December 2017, to any trauma-receiving emergency department in the eight participating trauma regions in the Netherlands, were included. A severe hemorrhage was defined as extracranial injury with > 20% body volume blood loss, an extremity amputation above the wrist or ankle, or a grade ≥ 4 visceral organ injury. The main outcome was to determine the proportion of patients with a severe hemorrhage who received pre-hospital treatment with tranexamic acid. A Generalized Linear Model (GLM) was performed to investigate the relationship between pre-hospital tranexamic acid treatment and 24 h mortality.

Results: A total of 477 patients had a severe hemorrhage, of whom 124 patients (26.0%) received tranexamic acid before arriving at the hospital. More than half (58.4%) of the untreated patients were suspected of a severe hemorrhage by EMS professionals. Patients treated with tranexamic acid had a significantly lower risk on 24 h mortality than untreated patients (OR 0.43 [95% CI 0.19-0.97]).

Conclusion: Approximately a quarter of the patients with a severe hemorrhage received tranexamic acid before arriving at the hospital, while a severe hemorrhage was suspected in more than half of the non-treated patients. Severely hemorrhaging patients treated with tranexamic acid before arrival at the hospital had a lower risk to die within 24 h after injury.

War-related traumatic brain injuries during the Syrian armed conflict in Damascus 2014-2017: a cohort study and a literature review

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BMC Emerg Med. 2023 Mar 29;23(1):35

Background: The decade-long Syrian armed conflict killed or injured more than 11% of the Syrian population. Head and neck injuries are the most frequent cause of war-related trauma, about half of which are brain injuries. Reports about Syrian brain trauma victims were published from neighboring countries; However, none are available from Syrian hospitals. This study aims to report war-related traumatic brain injuries from the Syrian capital.

Methods: We conducted a retrospective cohort study between 2014 and 2017 at Damascus Hospital, the largest public hospital in Damascus, Syria. Target patients were the victims of combat-related traumatic brain injuries who arrived alive and were admitted to the neurosurgery department or to another department but followed by the neurosurgery team. The collected data included the mechanism, type, and site of injury based on imaging findings; types of invasive interventions; intensive-care unit (ICU) admissions; as well as neurological status at admission and discharge including several severity scales.

Results: Our sample consisted of 195 patients; Ninety-six of them were male young adults, in addition to 40 females and 61 children. Injuries were caused by shrapnel in 127 (65%) cases, and by gunshots in the rest, and most of them (91%) were penetrating. Sixty-eight patients (35%) were admitted to the ICU, and 56 (29%) underwent surgery. Neurological impairment was reported in 49 patients (25%) at discharge, and the mortality rate during hospitalization was 33%. Mortality and neurological impairment associated significantly with higher values on clinical and imaging severity scores.

Conclusions: This study captured the full spectrum of war-related brain injuries of civilians and armed personnel in Syria without the delay required to transport patients to neighboring countries. Although the clinical presentation of injuries at admission was not as severe as that in previous reports, the inadequate resources (i.e., ventilators and operation rooms) and the lack of previous experience with similar injuries might have resulted in the higher mortality rate. Clinical and imaging severity scales can provide a handy tool in identifying cases with low probability of survival especially with the shortage of personal and physical resources.

Beta blockers in traumatic brain injury: a systematic review and meta-analysis

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Trauma Surg Acute Care Open. 2023 Mar 2;8(1):e001051.

Background: Traumatic brain injury (TBI) is a major cause of death and disability worldwide. Beta blockers have shown promise in improving mortality and functional outcomes after TBI. The aim of this article is to synthesize the available clinical data on the use of beta blockers in acute TBI.

Methods: A systematic search was conducted through MEDLINE, Embase, and Cochrane Central Register of Controlled Trials for studies including one or more outcomes of interest associated with use of beta blockers in TBI. Independent reviewers evaluated the quality of the studies and extracted data on all patients receiving beta blockers during their hospital stay compared with placebo or non-intervention. Pooled estimates, CIs, and risk ratios (RRs) or ORs were calculated for all outcomes.

Results: 13 244 patients from 17 studies were eligible for analysis. Pooled analysis demonstrated a significant mortality benefit of overall use of beta blocker (RR 0.8, 95% CI 0.68 to 0.94, I 2=75%). Subgroup analysis of patients with no preinjury use of beta blocker compared with patients on preinjury beta blockers showed no mortality difference (RR 0.99, 95% CI 0.7 to 1.39, I 2=84%). There was no difference in rate of good functional outcome at hospital discharge (OR 0.94, 95% CI 0.56 to 1.58, I 2=65%); however, there was a functional benefit at longer-term follow-up (OR 1.75, 95% CI 1.09 to 2.8, I 2=0%). Cardiopulmonary and infectious complications were more likely in patients who received beta blockers (RR 1.94, 95% CI 1.69 to 2.24, I 2=0%; RR 2.36, 95% CI 1.42 to 3.91, I 2=88%). Overall quality of the evidence was very low.

Conclusions: Use of beta blockers is associated with decreased mortality at acute care discharge as well as improved functional outcome at long-term follow-up. Lack of high-quality evidence limits definitive recommendations for use of beta blockers in TBI; therefore, high-quality randomized trials are needed to further elucidate the utility of beta blockers in TBI.

Ocular Motor Nerve Palsy After Traumatic Brain Injury: A Claims Database Study

Hwan Heo, Scott R Lambert

J Neuroophthalmol. 2023 Mar 1;43(1):131-136.

Background: Traumatic brain injury (TBI) is one of the common causes of ocular motor nerve (oculomotor nerve [CN3], trochlear nerve [CN4], and abducens nerve [CN6]) palsies, but there has been no large study of ocular motor nerve palsy caused by TBI. This study aimed to investigate the characteristics of and differences in ocular motor nerve palsy after TBI, according to patient age and severity of TBI.

Methods: This was a population-based retrospective cohort study that included patients who had ocular motor nerve palsy after TBI with ≥6 months of continuous enrollment using claims data from the IBM MarketScan Research Databases (2007-2016). We assessed sex, age at the first diagnosis of TBI, the severity of TBI, and the rates of strabismus procedures according to the age and severity of TBI. The rates of muscle transposition surgery and chemodenervation in CN3, CN4, and CN6 palsy were investigated.

Results: A total of 2,606,600 patients with TBI met the inclusion criteria. Among them, 1,851 patients (0.071%) had ocular motor nerve palsy after TBI. The median age of the patients was 39 (Q1-Q3: 19-54) years, and 42.4% of the patients were female. The median continuous enrollment period after the first diagnosis of TBI was 22 (Q1-Q3: 12-38) months. Of the 1,350,843 children with TBI, 454 (0.026%) had ocular motor nerve palsy. Of the 1,255,757 adults with TBI, 1,397 (0.111%) had ocular motor nerve palsy. Among these 1,851 patients, CN4 palsy (697, 37.7%) occurred most frequently, and strabismus procedures were performed in 237 patients (12.8%). CN6 palsy developed most frequently in children. More children (16.5%) underwent strabismus surgeries than adults (11.6%) ($P = 0.006$). The proportion of CN4 palsy (52.3%) was higher while the proportion of CN3 palsy (15.5%) was lower in patients with mild TBI than in patients with moderate-to-severe TBI ($P < 0.001$).

Conclusions: CN4 palsy developed most frequently among patients of all ages, and only approximately 13% of the patients underwent strabismus procedures for ocular motor nerve palsy after TBI. The rate of development of ocular motor nerve palsy was approximately 4.3 times lower in children than adults, and children most frequently had CN6 palsy after TBI.

Estimated Cost-Effectiveness of Implementing a Statewide Tranexamic Acid Protocol for the Management of Suspected Hemorrhage in the Prehospital Setting

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Prehosp Emerg Care. 2023;27(3):366-374.

Introduction: Hemorrhage is responsible for up to 40% of all traumatic deaths. The seminal CRASH-2 trial demonstrated a reduction in overall mortality following early tranexamic acid (TXA) administration to bleeding trauma patients. Following publication of the trial results, TXA has been incorporated into many prehospital trauma protocols. However, the cost-effectiveness of widespread TXA adoption by EMS is unknown.

Objective: To estimate the cost-effectiveness of statewide implementation of a TXA protocol.

Methods: The North Carolina Trauma Registry was queried to identify potential TXA patients using the a priori criteria of age ≥18 years, suspected hemorrhage, penetrating or blunt injury, and prehospital blood pressure <90 mmHg and heart rate >110 bpm. Using life tables adjusted for age, sex, and race, and the absolute risk reductions in mortality with early TXA administration reported in the literature, the life-years gained were calculated for each potential life saved. Implementation costs consisted of initial stocking, training, and replacement costs. Projected reduction in hospitalization costs were based on estimates reported in the literature. Economic analyses were conducted from societal and state EMS system perspectives. To assess the robustness of the model, univariate and bivariate sensitivity analyses were performed on selected input variables.

Results: Based on the TXA inclusionary criteria, 159 patients could potentially receive TXA per year. In the base-case scenario with a projected absolute mortality reduction of 3%, an additional 4.8 lives per year in NC would be saved, with an estimated 191 total life-years gained. The statewide implementation and operation cost was $305,122 in year 1, and continued operating costs were $6,042 in years 2 and 3, yielding a cost per life saved of $63,967 in year 1 and $1,267 in years 2 and 3. The cost per life-year gained was $1,595 in year 1 and $32 in years 2 and 3. Annual hospitalization costs would potentially be reduced by $1,828,072.

Conclusion: Previous studies have demonstrated the clinical effectiveness of early TXA administration to patients with hemorrhage. Our modeling of the financial implications and clinical benefits of implementing a statewide TXA protocol suggests that prehospital TXA is a cost-effective treatment.

A systematic review of sufentanil for the management of adults with acute pain in the emergency department and pre-hospital setting

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Am J Emerg Med. 2023 Aug:70:10-18.

Background: Pain is commonly encountered in the Emergency Department (ED) and pre-hospital setting and often requires opioid analgesia. We sought to synthesize the available evidence on the effectiveness of sufentanil for acute pain relief for adult patients in the pre-hospital or ED setting.

Methods: This systematic review was conducted in accordance with PRISMA guidelines. Medline, Embase, Cochrane CENTRAL, and CINAHL were searched from inception to February 1, 2022. The grey literature was also searched. We included randomized controlled trials of adult patients with acute pain who were treated with sufentanil. Two reviewers independently completed screening, full text review, and data extraction. Primary outcome was reduction in pain. Secondary outcomes included adverse events, need for rescue analgesia, and patient and provider satisfaction. Risk of bias was assessed using the Cochrane Risk of Bias 2 tool. A meta-analysis was not performed due to heterogeneity.

Results: Of 1120 unique citations, four studies (3 ED and 1 pre-hospital) met full inclusion criteria (n = 467 participants). The overall quality of the included studies was high. Intranasal (IN) sufentanil was superior to placebo for pain relief at 30 min (difference 20.8%, 95% CI 4.0-36.2%, p = 0.01). Both IN (two studies) and IV sufentanil (one study) were comparable to IV morphine. Mild adverse events were common and there was a higher propensity for minor sedation in patients receiving sufentanil. There were no serious adverse events requiring advanced interventions.

Conclusion: Sufentanil was comparable to IV morphine and was superior to placebo for rapid relief of acute pain in the ED setting. The safety profile of sufentanil is similar to IV morphine in this setting, with minimal concern for serious adverse events. The intranasal formulation may provide an alternative, rapid, non-parenteral route that could benefit our unique emergency department and pre-hospital patient population. Due to the overall small sample size of this review, larger studies are required to confirm safety.

Impact of time and distance on outcomes following tourniquet use in civilian and military settings: A scoping review

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Injury. 2023 May;54(5):1236-1245.

Background: The last two decades have seen the reintroduction of tourniquets into guidelines for the management of acute limb trauma requiring hemorrhage control. Evidence supporting tourniquet application has demonstrated low complication rates in modern military settings involving rapid evacuation timeframes. It is unclear how these findings translate to patients who have prolonged transport times from injury in rural settings. This scoping review investigates the relationship between time and distance on metabolic complications, limb salvage and mortality following tourniquet use in civilian and military settings.

Methods: A systematic search strategy was conducted using PubMed, Embase, and SafetyLit databases. Study characteristics, setting, mechanism of injury, prehospital time, tourniquet time, distance, limb salvage, metabolic response, mortality, and tourniquet removal details were extracted from eligible studies. Descriptive statistics were recorded, and studies were grouped by ischemia time (< 2 h, 2-4 h, or > 4 h).

Results: The search identified 3103 studies, from which 86 studies were included in this scoping review. Of the 86 studies, 55 studies were primarily in civilian environments and 32 were based in military settings. One study included both settings. Blast injury was the most common mechanism of injury sustained by patients in military settings (72.8% [5968/8200]) followed by penetrating injury (23.5% [1926/8200]). In contrast, in civilian settings penetrating injury was the most common mechanism (47.7% [1633/3426]) followed by blunt injury (36.4% [1246/3426]). Tourniquet time was reported in 66/86 studies. Tourniquet time over four hours was associated with reduced limb salvage rates (57.1%) and higher mortality rates (7.1%) compared with a tourniquet time of less than two hours. The overall limb salvage and mortality rates were 69.6% and 6.7% respectively. Metabolic outcomes were reported in 28/86 studies with smaller sample sizes and inconsistencies in which parameters were reported.

Conclusion: This scoping review presents literature describing comparatively safe tourniquet application when used for less than two hours duration. However, there is limited research describing prolonged tourniquet application or when used for protracted distances, such that the impact of tourniquet release time on metabolic outcomes and complications remains unclear. Prospective studies utilizing the development of an international database to provide this dataset is required.

Turning Back the Clock: Prehospital Antibiotics for Patients With Septic Shock: Let Us Act at the Right Time

Romain Jouffroy, Papa Gueye, Benoît Vivien

Crit Care Med. 2023 Apr 1;51(4):e97-e98.

No abstract available

Equivalence of the top-down manoeuvre and bottom-up manoeuvre in speed and accuracy of identifying the cricothyroid membrane: a prospective randomised cross-over study

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BMC Emerg Med. 2023 Mar 16;23(1):29.

Background: Accurate identification of the cricothyroid membrane is crucial for successful cricothyrotomy; however, a manoeuvre that helps identify it both accurately and quickly remains unclear. The effectiveness of the so-called 'bottom-up manoeuvre' has never been investigated. This study aimed to examine whether the bottom-up manoeuvre is as rapid and accurate as the conventional 'top-down manoeuvre' at identifying the cricothyroid membrane.

Methods: This study was a prospective randomised cross-over trial conducted at an academic medical centre between 2018 and 2019. Fifth-year medical students participated. The students were trained in the use of either the top-down manoeuvre or the bottom-up manoeuvre first. Each student subsequently performed the technique once on a volunteer. The students were then taught and practiced the other manoeuvre as well. The accuracy of cricothyroid membrane identification and the time taken by successful participants only were measured and compared between the manoeuvres using equivalence tests with two one-sided tests.

Results: A total of 102 medical students participated in this study and there was no missing data. The accuracy of identification and time required for success were similar between the top-down manoeuvre and the bottom-up manoeuvre (65.7% vs. 70.6%, taking 13.8 s [interquartile range (IQR): 9.4-17.5] vs. 15.5 s [IQR: 11.5-19.9], respectively). The success rate was statistically equivalent (rate difference, 4.9%; 90% confidence interval [CI], -5.8 to 15.6; equivalence margin, -20.0 to 20.0). The time required for success was also statistically equivalent (median difference, 1.7 s; 90% CI, -0.2 to 3.3; equivalence margin, -4.0 to 4.0).

Conclusion: Among students first trained in both manoeuvres for identifying the cricothyroid membrane, the speed and accuracy of identification were similar between those using the bottom-up manoeuvre and those using the top-down manoeuvre.

Permissive hypoventilation equally effective to maintain oxygenation as positive pressure ventilation after porcine class III hemorrhage and whole blood resuscitation

Tomas Karlsson, Mikael Gellerfors, Jenny Gustavsson, Mattias Günther

Transfusion. 2023 May:63 Suppl 3:S213-S221.

Background: Prehospital anesthesia may lead to circulatory collapse after severe hemorrhage. It is possible that permissive hypoventilation, refraining from tracheal intubation and accepting spontaneous ventilation, decreases this risk, but it is not known if oxygen delivery can be maintained. We investigated the feasibility of permissive hypoventilation after class III hemorrhage and whole blood resuscitation in three prehospital phases: 15 min on-scene, 30 min whole blood resuscitation, and 45 min after.

Study design and methods: 19 crossbred swine, mean weight 58.5 kg, were anesthetized with ketamine/midazolam and hemorrhaged to a mean (SD) 1298 (220) mL (33%) and randomized to permissive hypoventilation (n = 9) or positive pressure ventilation with FiO2 21% (n = 10).

Results: In permissive hypoventilation versus positive pressure ventilation, indexed oxygen delivery (DO2 I) decreased to mean (SD) 4.73 (1.06) versus 3.70 (1.13) mL min-1 kg-1 after hemorrhage and increased to 8.62 (2.09) versus 6.70 (1.56) mL min-1 kg-1 at completion of resuscitation. DO2 I, indexed oxygen consumption (VO2 I), and arterial saturation (SaO2) did not differ. Permissive hypoventilation increased the respiratory rate and increased pCO2 . Positive pressure ventilation did not deteriorate circulation. Cardiac index (CI), systolic arterial pressure (SAP), hemoglobin (Hb), and heart rate did not differ.

Discussion: Permissive hypoventilation and positive pressure ventilation were equally effective to maintain oxygen delivery in all phases. A respiratory rate of 40 was feasible, showing no signs of respiratory fatigue for 90 min, indicating that whole blood resuscitation may be prioritized in select patients with severe hemorrhage and spontaneous breathing.

Comparison of oropharyngeal leak pressure of LMA Protector and LMA-ProSeal in different head and neck positions in anaesthetized and paralyzed patients; A prospective randomized study

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Indian J Anaesth. 2023 Feb;67(2):201-206.

Background and aims: Oropharyngeal leak pressure (OLP) of LMA Protector is reported to be higher compared to other second generation supraglottic devices (SGDs) indicating better seal with patient's airway and hence enhanced safety. To ascertain its benefit in patients undergoing surgeries where head and neck position other than neutral is required, we conducted a prospective randomized study to compare OLP of LMA Protector with LMA-ProSeal (PLMA) with head and neck in neutral, extension, flexion, and rotation position.

Methods: 80 American Society of Anesthesiologists (ASA) I-II patients aged more than 18 years undergoing elective surgery under general anaesthesia were recruited. Patients were randomized in the LMA Protector or PLMA group. After induction of anaesthesia, OLP was measured in both the groups in different head and neck position. The insertion characteristics of both SGDs were also recorded and compared.

Results: The OLP of LMA Protector and PLMA was found to be comparable in neutral head position ($p = 0.08$). There was no significant difference in OLP of both devices in extension, flexion, or head rotation. In both the study groups, head extension position led to significant decrease in OLP compared to supine position. With the flexion and rotation positioning of head and neck, significant increase in OLP in each group was noted.

Conclusion: The OLP of LMA Protector and PLMA are comparable in different head and neck position. With both the devices, there was significant decrease in OLP with extension whereas significant increase was noted in flexion and rotation of head and neck.

Chest Tubes Are Painful

Min P Kim

Ann Thorac Surg. 2023 Apr;115(4):843-844.

No abstract available

Military Burn Care and Burn Disasters

Booker King, Leopoldo C Cancio, James C Jeng

Surg Clin North Am. 2023 Jun;103(3):529-538.

Abstract

Mass-casualty incidents can occur because of natural disasters; industrial accidents; or intentional attacks against civilian, police, or in case of combat, military forces. Depending on scale and type of incident, burn casualties often with a variety of concomitant injuries can be anticipated. The treatment of life-threatening traumatic injuries should take precedent but the stabilization, triage, and follow-on care of these patients will require local, state, and often regional coordination and support.

We are all exposed, but some are more exposed than others

Boris Kingma, Wendy Sullivan-Kwantes, John Castellani, Karl Friedl, François Haman

Int J Circumpolar Health. 2023 Dec;82(1):2199492

Abstract

This paper defines functional cold exposure zones that illustrate whether a person is at risk of developing physical performance loss or cold weather injuries. Individual variation in body characteristics, activity level, clothing and protective equipment all contribute to variation in the effective exposure. Nevertheless, with the right education, training, and cold-adapted behaviours the exposure differences might not necessarily lead to increased risk for cold injury. To support the preparation process for cold weather operations, this paper presents a biophysical analysis explaining how much cold exposure risk can vary between individuals in the same environment. The results suggest that smaller persons are prone to be underdressed for moderate activity levels and larger persons are prone to be overdressed. The consequences of these discrepancies place people at different risks for performance loss or cold weather injuries. Nonetheless, even if all are well-dressed at the whole-body level, variation in hand morphology is also expected to influence hand skin temperatures that can be maintained; with smaller hands being more prone to reach skin temperatures associated with dexterity loss or cold weather injuries. In conclusion, this work focusses on bringing cold science to the Arctic warrior, establishing that combating cold stress is not a one size fits all approach.

The reality of advanced airway management during out of hospital cardiac arrest; why did paramedics deviate from their allocated airway management strategy during the AIRWAYS-2 randomised trial?

K Kirby, M Lazaroo, J Green, H Hall, R Pilbery, G A Whitley, S Voss, J Benger

Resusc Plus. 2023 Feb 18:13:100365. 2023 Mar.

Background: AIRWAYS-2 was a large multi-centre cluster randomised controlled trial investigating the effect on functional outcome of a supraglottic airway device (i-gel) versus tracheal intubation (TI) as the initial advanced airway during out-of-hospital cardiac arrest. We aimed to understand why paramedics deviated from their allocated airway management algorithm during AIRWAYS-2.

Methods: This study employed a pragmatic sequential explanatory design utilising retrospective study data collected during the AIRWAYS-2 trial. Airway algorithm deviation data were analysed to categorise and quantify the reasons why paramedics did not follow their allocated strategy of airway management during AIRWAYS-2. Recorded free text entries provided additional context to the paramedic decision-making related to each category identified.

Results: In 680 (11.7%) of 5800 patients the study paramedic did not follow their allocated airway management algorithm. There was a higher percentage of deviations in the TI group (399/2707; 14.7%) compared to the i-gel group (281/3088; 9.1%). The predominant reason for a paramedic not following their allocated airway management strategy was airway obstruction, occurring more commonly in the i-gel group (109/281; 38.7%) versus (50/399; 12.5%) in the TI group.

Conclusion: There was a higher proportion of deviations from the allocated airway management algorithm in the TI group (399; 14.7%) compared to the i-gel group (281; 9.1%). The most frequent reason for deviating from the allocated airway management algorithm in AIRWAYS-2 was obstruction of the patient's airway by fluid. This occurred in both groups of the AIRWAYS-2 trial, but was more frequent in the i-gel group.

A narrative review of prehospital hemorrhagic shock treatment with non-blood product medications

Caleb D Knight, Vikhyat Bebarta, Michael A Meledeo, Evan Ross, Xiaowu Wu, James Bynum, Steven Schauer, Todd Getz, Michael April

Transfusion. 2023 May:63 Suppl 3:S256-S262.

Background: Hemorrhagic shock remains a leading cause of death in both military and civilian trauma casualties. While standard of care involves blood product administration, maintaining normothermia, and restoring hemostatic function, alternative strategies to treat severe hemorrhage at or near the point of injury are needed. We reviewed adjunct solutions for managing severe hemorrhage in the prehospital environment.

Methods: We performed a literature review by searching PubMed with a combination of several keywords. Additional pertinent studies were identified by crossreferencing primary articles. Clinical experience of each author was also considered.

Results: We identified several promising antishock therapies that can be utilized in the prehospital setting: ethinyl estradiol sulfate (EES), polyethylene glycol 20,000 (PEG20K), C1 esterase inhibitors (e.g. Berinert, Cinryze), cyclosporin A, niacin, bortezomib, rosiglitazone, icatibant, diazoxide, and valproic acid (VPA).

Conclusion: Several studies show promising adjunct treatment options in the management of severe prehospital hemorrhage. While some are rarely used, many others are readily available and commonly utilized for other indications. This suggests the potential for future use in resourcelimited settings. Human studies and case reports supporting their use are currently lacking.

Warning: Tourniquets Risk Frostbite in Cold Weather

John F Kragh Jr, Daniel K O'Conor

J Spec Oper Med. 2023 Mar 15;23(1):9-16.

Abstract

We sought to better understand the frostbite risk during first-aid tourniquet use by reviewing information relevant to an association between tourniquet use and frostbite. However, there is little information concerning this subject, which may be of increasing importance because future conflicts against near-peer competitors may involve extreme cold weather environments. Historically, clinical frostbite cases with tourniquet use occurred in low frequency but in high severity when leading to limb amputation. The physiologic response of vasoconstriction to cold exposure leads to limb cooling and causes a reduction of limb blood flow, but cold-induced vasodilation ensues as periodic fluctuations that increase blood flow to hands and feet. In animal experiments, tourniquet use increased the development of frostbite. Evidence from human experiments also supports an association between tourniquet use and frostbite. Clinical guidance for caregiving to casualties at risk for frostbite with tourniquet use had previously been provided but slowly and progressively dropped out of documents. Conclusions: The cause of frostbite was deduced to be a sufficiently negative heat-transfer trend in local tissues, which tourniquet use may worsen because of decreasing tissue perfusion. An association between tourniquet use and frostbite exists but not as cause and effect. Tourniquet use increased the risk of the cold causing frostbite by allowing faster cooling of a limb because of reduced blood flow and lack of cold-induced vasodilation. Care providers above the level of the lay public are warned that first-aid tourniquet use in low-temperature (<0°C [<32°F]) environmental conditions risks frostbite.

A Novel Device With Improved Outcomes for Tube Thoracostomy

Aimee K LaRiccia, Timothy Wolff, Keshav Deshpande, M Chance Spalding

J Surg Res. 2023 Mar:283:1100-1105.

Introduction: Tube thoracostomy is a common procedure for which competency is expected of all trauma providers, both surgical and nonsurgical. Although surgery residents have fewer complications than other resident specialties, complications relating to position and insertion are reported. We hypothesized the use of our novel chest tube placement device will improve chest tube placement efficiency while maintaining accuracy compared to the open Kelly clamp technique across multiple specialties.

Methods: A swine lab was conducted through an approved Institutional Animal Care and Use Committee device testing protocol. After a preprocedure, tutorial participants placed chest tubes with the device and Kelly clamps through predetermined incision sites. Placement positioning was determined by a postplacement chest X-ray. One way analysis of variance was used for intratechnique comparisons. Time to placement was compared using paired t-test; P- values of <0.05 were considered significant.

Results: Intrathoracic device placement occurred with 94.4% (N = 68) of placements compared to 93.1% (N = 67) of Kelly clamp placements (P = 0.73). The device-placed chest tubes were apically positioned 94.4% (N = 68) compared to 66.7% (N = 48) ($P < 0.01$) of Kelly clamp-placed chest tubes. Novel device use chest tube placement was significantly faster with a mean time of 39.3 (±27.7) s compared to 61.5 (±38.6) s for the Kelly clamp ($P < 0.01$).

Conclusions: In this proof of concept study, our chest tube placement device improved efficiency and accuracy in chest tube placement when compared to the open Kelly clamp technique. This finding was consistent across thoracic trauma providers, including general surgery residents.

Trends in Traumatic Brain Injury Among U.S. Service Members Deployed in Iraq and Afghanistan, 2002-2016

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Am J Prev Med. 2023 Aug;65(2):230-238.

Introduction: Traumatic brain injury (TBI) is a major health issue for service members deployed and is more common in recent conflicts; however, a thorough understanding of risk factors and trends is not well described. This study aims to characterize the epidemiology of TBI in U.S. service members and the potential impacts of changes in policy, care, equipment, and tactics over the 15 years studied.

Methods: Retrospective analysis of U.S. Department of Defense Trauma Registry data (2002-2016) was performed on service members treated for TBI at Role 3 medical treatment facilities in Iraq and Afghanistan. Risk factors and trends in TBI were examined in 2021 using Joinpoint regression and logistic regression.

Results: Nearly one third of 29,735 injured service members (32.4%) reaching Role 3 medical treatment facilities had TBI. The majority sustained mild (75.8%), followed by moderate (11.6%) and severe (10.6%) TBI. TBI proportion was higher in males than in females (32.6% vs 25.3%; $p<0.001$), in Afghanistan than in Iraq (43.8% vs 25.5%; $p<0.001$), and in battle than in nonbattle (38.6% vs 21.9%; $p<0.001$). Patients with moderate or severe TBI were more likely to have polytrauma ($p<0.001$). TBI proportion increased over time, primarily in mild TBI ($p=0.02$), slightly in moderate TBI ($p=0.04$), and most rapidly between 2005 and 2011, with a 2.48% annual increase.

Conclusions: One third of injured service members at Role 3 medical treatment facilities experienced TBI. Findings suggest that additional preventive measures may decrease TBI frequency and severity. Clinical guidelines for field management of mild TBI may reduce the burden on evacuation and hospital systems. Additional capabilities may be needed for military field hospitals.

Analysis of tourniquet pressure over military winter clothing and a short review of combat casualty care in cold weather warfare

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Int J Circumpolar Health. 2023 Dec;82(1):2194141.

Abstract

Cold weather warfare is of increasing importance. Haemorrhage is the most common preventable cause of death in military conflicts. We analysed the pressure of the Combat Application Tourniquet® Generation 7 (CAT), the SAM® Extremity Tourniquet (SAMXT) and the SOF® Tactical Tourniquet Wide Generation 4 (SOFTT) over different military cold weather clothing setups with a leg tourniquet trainer. We conducted a selective PubMed search and supplemented this with own experiences in cold weather medicine. The CAT and the SAMXT both reached the cut off value of 180mmHg in almost all applications. The SOFTT was unable to reach the 180mmHg limit in less than 50% of all applications in some clothing setups. We outline the influence of cold during military operations by presenting differences between military and civilian cold exposure. We propose a classification of winter warfare and identify caveats and alterations of Tactical Combat Casualty Care in cold weather warfare, with a special focus on control of bleeding. The application of tourniquets over military winter clothing is successful in principle, but effectiveness may vary for different tourniquet models. Soldiers are more affected and impaired by cold than civilians. Military commanders must be made aware of medical alterations in cold weather warfare.

Prehospital Guidelines for the Management of Traumatic Brain Injury - 3rd Edition

Al Lulla, Angela Lumba-Brown, Annette M Totten, Patrick J Maher, Neeraj Badjatia, Randy Bell, Christina T J Donayri, Mary E Fallat, Gregory W J Hawryluk, Scott A Goldberg, Halim M A Hennes, Steven P Ignell, Jamshid Ghajar, Brian P Krzyzaniak, E Brooke Lerner, Daniel Nishijima, Charles Schleien, Stacy Shackelford, Erik Swartz, David W Wright, Rachel Zhang, Andy Jagoda, Bentley J Bobrow

Prehosp Emerg Care. 2023;27(5):507-538.

No abstract available

Crystalloid volume is associated with short-term morbidity in children with severe traumatic brain injury: An Eastern Association for the Surgery of Trauma multicenter trial post hoc analysis

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J Trauma Acute Care Surg. 2023 Jul 1;95(1):78-86.

Objective: This study examined differences in clinical and resuscitation characteristics between injured children with and without severe traumatic brain injury (sTBI) and aimed to identify resuscitation characteristics associated with improved outcomes following sTBI.

Methods: This is a post hoc analysis of a prospective observational study of injured children younger than 18 years (2018-2019) transported from the scene, with elevated shock index pediatric-adjusted on arrival and head Abbreviated Injury Scale score of ≥3. Timing and volume of resuscitation products were assessed using χ 2t test, Fisher's exact t test, Kruskal-Wallis, and multivariable logistic regression analyses.

Results: There were 142 patients with sTBI and 547 with non-sTBI injuries. Severe traumatic brain injury patients had lower initial hemoglobin (11.3 vs. 12.4, $p < 0.001$), greater initial international normalized ratio (1.4 vs. 1.1, $p < 0.001$), greater Injury Severity Score (25 vs. 5, $p < 0.001$), greater rates of ventilator (59% vs. 11%, $p < 0.001$) and intensive care unit (ICU) requirement (79% vs. 27%, $p < 0.001$), and more inpatient complications (18% vs. 3.3%, $p < 0.001$). Severe traumatic brain injury patients received more prehospital crystalloid (25% vs. 15%, $p = 0.008$), ≥1 crystalloid boluses (52% vs. 24%, $p < 0.001$), and blood transfusion (44% vs. 12%, $p < 0.001$) than non-sTBI patients. Among sTBI patients, receipt of ≥1 crystalloid bolus ($n = 75$) was associated with greater ICU need (92% vs. 64%, $p < 0.001$), longer median ICU (6 vs. 4 days, $p = 0.027$) and hospital stay (9 vs. 4 days, $p < 0.001$), and more in-hospital complications (31% vs. 7.5%, $p = 0.003$) than those who received <1 bolus ($n = 67$). These findings persisted after adjustment for Injury Severity Score (odds ratio, 3.4-4.4; all $p < 0.010$).

Conclusion: Pediatric trauma patients with sTBI received more crystalloid than those without sTBI despite having a greater international normalized ratio at presentation and more frequently requiring blood products. Excessive crystalloid may be associated with worsened outcomes, including in-hospital mortality, seen among pediatric sTBI patients who received ≥1 crystalloid bolus. Further attention to a crystalloid sparing, early transfusion approach to resuscitation of children with sTBI is needed.

Relationship between combat-related traumatic injury and ultrashort term heart rate variability in a UK military cohort: findings from the ADVANCE study

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BMJ Mil Health. 2023 Mar 29:Online ahead of print.

Introduction: Combat-related traumatic injury (CRTI) has been linked to an increased cardiovascular disease (CVD) risk. The long-term impact of CRTI on heart rate variability (HRV)-a robust CVD risk marker-has not been explored. This study investigated the relationship between CRTI, the mechanism of injury and injury severity on HRV.

Methods: This was an analysis of baseline data from the ArmeD SerVices TrAuma and RehabilitatioN OutComE (ADVANCE) prospective cohort study. The sample consisted of UK servicemen with CRTI sustained during deployment (Afghanistan, 2003-2014) and an uninjured comparison group who were frequency matched to the injured group based on age, rank, deployment period and role in theatre. Root mean square of successive differences (RMSSD) was measured as a measure of ultrashort term HRV via <16 s continuous recording of the femoral arterial pulse waveform signal (Vicorder). Other measures included injury severity (New Injury Severity Scores (NISS)) and injury mechanism.

Results: Overall, 862 participants aged 33.9±5.4 years were included, of whom 428 (49.6%) were injured and 434 (50.3%) were uninjured. The mean time from injury/deployment to assessment was 7.91±2.05 years. The median (IQR) NISS for those injured was 12 (6-27) with blast being the predominant injury mechanism (76.8%). The median (IQR) RMSSD was significantly lower in the injured versus the uninjured (39.47 ms (27.77-59.77) vs 46.22 ms (31.14-67.84), p<0.001). Using multiple linear regression (adjusting for age, rank, ethnicity and time from injury), geometric mean ratio (GMR) was reported. CRTI was associated with a 13% lower RMSSD versus the uninjured group (GMR 0.87, 95% CI 0.80-0.94, p<0.001). A higher injury severity (NISS ≥25) (GMR 0.78, 95% CI 0.69-0.89, p<0.001) and blast injury (GMR 0.86, 95% CI 0.79-0.93, p<0.001) were also independently associated with lower RMSSD.

Conclusion: These results suggest an inverse association between CRTI, higher severity and blast injury with HRV. Longitudinal studies and examination of potential mediating factors in this CRTI-HRV relationship are needed.

Cumulative Blast Exposure Estimate Model for Special Operations Forces Combat Soldiers

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J Neurotrauma. 2023 Feb;40(3-4):318-325.

Abstract

Special Operations Forces (SOF) Service members endure frequent exposures to blast and overpressure mechanisms given their high training tempo. The link between cumulative subconcussive blasts on short- and long-term neurological impairment is largely understudied. Neurodegenerative diseases such as brain dysfunction, cognitive decline, mild cognitive impairment, and dementia may develop with chronic exposures. This hypothesis remains unproven because of lack of ecologically valid occupational blast exposure surveillance among SOF Service members. The purpose of the study was to measure occupational blast exposures in a close quarter battle (CQB) training environment and to use those outcomes to develop a pragmatic cumulative blast exposure (CBE) estimate model. Four blast silhouettes equipped with a field-deployable wireless blast gauge system were positioned in breaching positions during CQB training scenarios. Silhouettes were exposed to flashbangs and three interior breaching charges (single strand roll-up interior charge, 300 grain (gr) explosive cutting tape (ECT), and Jelly charge). Mean blast measures were calculated for each silhouette for flashbangs (n = 93), single strand roll-up interior charge (n = 80), 300 gr ECT (n = 28), and Jelly charge (n = 71). Mean peak blast pressures per detonation are reported as follows: (1) flashbangs (1.97 pounds per square inch [psi]); (2) single strand roll-up interior charge (3.88 psi); (3) 300 gr ECT (2.78 psi); and (4) Jelly charge (1.89 psi). Pragmatic CBE estimates for SOF Service members suggest 36.8 psi, 184 psi, and 2760 psi may represent daily, weekly, and training cycle cumulative pressure exposures. Estimating blast exposures during routine CQB training can be determined from empirical measures taken in CQB environments. Factoring in daily, weekly, training cycle, or even career length may reasonably estimate cumulative occupational training blast exposures for SOF Service members. Future work may permit more granular exposure estimates based on operational blast exposures and those experienced by other military occupational specialties.

Pre-hospital freeze-dried plasma for critical bleeding after trauma: A pilot randomized controlled trial

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Acad Emerg Med. 2023 Oct;30(10):1013-1019.

Objectives: Transfusion of a high ratio of plasma to packed red blood cells (PRBCs), to treat or prevent acute traumatic coagulopathy, has been associated with survival after major trauma. However, the effect of prehospital plasma on patient outcomes has been inconsistent. The aim of this pilot trial was to assess the feasibility of transfusing freeze-dried plasma with red blood cells (RBCs) using a randomized controlled design in an Australian aeromedical prehospital setting.

Methods: Patients attended by helicopter emergency medical service (HEMS) paramedics with suspected critical bleeding after trauma managed with prehospital RBCs were randomized to receive 2 units of freeze-dried plasma (Lyoplas N-w) or standard care (no plasma). The primary outcome was the proportion of eligible patients enrolled and provided the intervention. Secondary outcomes included preliminary data on effectiveness, including mortality censored at 24 h and at hospital discharge, and adverse events.

Results: During the study period of June 1 to October 31, 2022, there were 25 eligible patients, of whom 20 (80%) were enrolled in the trial and 19 (76%) received the allocated intervention. Median time from randomization to hospital arrival was 92.5 min (IQR 68-101.5 min). Mortality may have been lower in the freeze-dried plasma group at 24 h (RR 0.24, 95% CI 0.03-1.73) and at hospital discharge (RR 0.73, 95% CI 0.24-2.27). No serious adverse events related to the trial interventions were reported.

Conclusions: This first reported experience of freeze-dried plasma use in Australia suggests prehospital administration is feasible. Given longer prehospital times typically associated with HEMS attendance, there is potential clinical benefit from this intervention and rationale for a definitive trial.

Use of Intranasal Analgesia in French Armed Forces: A Cross-Sectional Survey

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J Spec Oper Med. 2023 Oct 5;23(3):39-43.

Background: Pain management is essential in military medicine, particularly in Tactical Combat Casualty Care (TCCC) during deployments in remote and austere settings. The few previously published studies on intranasal analgesia (INA) focused only on the efficacy and onset of action of the medications used (ketamine, sufentanil, and fentanyl). Side-effects were rarely reported. The aim of our study was to evaluate the use of intranasal analgesia by French military physicians.

Methods: We carried out a multicentric survey between 15 January and 14 April 2020. The survey population included all French military physicians in primary-care centers (n = 727) or emergency departments (n = 55) regardless of being stationed in mainland France or French overseas departments and territories.

Results: We collected 259 responses (33% responsiveness rate), of which 201 (77.6%) physicians reported being familiar with INA. However, regarding its use, of the 256 physicians with completed surveys, only 47 (18.3%) had already administered it. Emergency medicine physicians supporting highly operational units (e.g., Special Forces) were more familiar with this route of administration and used it more frequently. Ketamine was the most common medication used (n = 32; 57.1%). Finally, 234 (90%) respondents expressed an interest in further education on INA.

Conclusion: Although a majority of French military physicians who replied to the survey were familiar with INA, few used it in practice. This route of administration seems to be a promising medication for remote and austere environments. Specific training should, therefore, be recommended to spread and standardize its use.

PREHOSPITAL PLASMA IS NONINFERIOR TO WHOLE BLOOD FOR RESTORATION OF CEREBRAL OXYGENATION IN A RHESUS MACAQUE MODEL OF TRAUMATIC SHOCK AND HEMORRHAGE

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Shock. 2023 Jul 1;60(1):146-152.

Introduction: Traumatic shock and hemorrhage (TSH) is a leading cause of preventable death in military and civilian populations. Using a TSH model, we compared plasma with whole blood (WB) as prehospital interventions, evaluating restoration of cerebral tissue oxygen saturation (CrSO 2), systemic hemodynamics, colloid osmotic pressure (COP) and arterial lactate, hypothesizing plasma would function in a noninferior capacity to WB, despite dilution of hemoglobin (Hgb).

Methods: Ten anesthetized male rhesus macaques underwent TSH before randomization to receive a bolus of O(-) WB or AB(+) plasma at T0. At T60, injury repair and shed blood (SB) to maintain MAP > 65 mm Hg began, simulating hospital arrival. Hematologic data and vital signs were analyzed via t test and two-way repeated measures ANOVA, data presented as mean ± SD, significance = $P < 0.05$.

Results: There were no significant group differences for shock time, SB volume, or hospital SB. At T0, MAP and CrSO 2 significantly declined from baseline, though not between groups, normalizing to baseline by T10. Colloid osmotic pressure declined significantly in each group from baseline at T0 but restored by T30, despite significant differences in Hgb (WB 11.7 ± 1.5 vs. plasma 6.2 ± 0.8 g/dL). Peak lactate at T30 was significantly higher than baseline in both groups (WB 6.6 ± 4.9 vs. plasma 5.7 ± 1.6 mmol/L) declining equivalently by T60.

Conclusions: Plasma restored hemodynamic support and CrSO 2 , in a capacity not inferior to WB, despite absence of additional Hgb supplementation. This was substantiated via return of physiologic COP levels, restoring oxygen delivery to microcirculation, demonstrating the complexity of restoring oxygenation from TSH beyond simply increasing oxygen carrying capacity.

Factors that influence the administration of tranexamic acid (TXA) to trauma patients in prehospital settings: a systematic review

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BMJ Open. 2023 May 31;13(5):e073075.

Objective: In the UK there are around 5400 deaths annually from injury. Tranexamic acid (TXA) prevents bleeding and has been shown to reduce trauma mortality. However, only 5% of UK major trauma patients who are at risk of haemorrhage receive prehospital TXA. This review aims to examine the evidence regarding factors influencing the prehospital administration of TXA to trauma patients.

Design: Systematic literature review.

Data sources: AMED, CENTRAL, CINAHL, Cochrane Database of Systematic Reviews, Conference Proceedings Citation Index-Science, Embase and MEDLINE were searched from January 2010 to 2020; searches were updated in June 2022.

Clinicaltrials: gov and OpenGrey were also searched and forward and backwards citation chasing performed.

Eligibility criteria: All primary research reporting factors influencing TXA administration to trauma patients in the prehospital setting was included.

Data extraction and synthesis: Two independent reviewers performed the selection process, quality assessment and data extraction. Data were tabulated, grouped by setting and influencing factor and synthesised narratively.

Results: Twenty papers (278 249 participants in total) were included in the final synthesis; 13 papers from civilian and 7 from military settings. Thirteen studies were rated as 'moderate' using the Effective Public Health Practice Project Quality Assessment Tool. Several common factors were identified: knowledge and skills; consequences and social influences; injury type (severity, injury site and mechanism); protocols; resources; priorities; patient age; patient sex.

Conclusions: This review highlights an absence of high-quality research. Preliminary evidence suggests a host of system and individual-level factors that may be important in determining whether TXA is administered to trauma patients in the prehospital setting.

Funding and registration: This review was supported by Research Capability Funding from the South Western Ambulance Service NHS Foundation Trust and the National Institute for Health Research Applied Research Collaboration South West Peninsula.

Incidence of rescue surgical airways after attempted orotracheal intubation in the emergency department: A National Emergency Airway Registry (NEAR) Study

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Am J Emerg Med. 2023 Jun:68:22-27.

Background: Cricothyrotomy is a critical technique for rescue of the failed airway in the emergency department (ED). Since the adoption of video laryngoscopy, the incidence of rescue surgical airways (those performed after at least one unsuccessful orotracheal or nasotracheal intubation attempt), and the circumstances where they are attempted, has not been characterized.

Objective: We report the incidence and indications for rescue surgical airways using a multicenter observational registry.

Methods: We performed a retrospective analysis of rescue surgical airways in subjects ≥14 years of age. We describe patient, clinician, airway management, and outcome variables.

Results: Of 19,071 subjects in NEAR, 17,720 (92.9%) were ≥14 years old with at least one initial orotracheal or nasotracheal intubation attempt, 49 received a rescue surgical airway attempt, an incidence of 2.8 cases per 1000 (0.28% [95% confidence interval 0.21 to 0.37]). The median number of airway attempts prior to rescue surgical airways was 2 (interquartile range 1, 2). Twenty-five were in trauma victims (51.0% [36.5 to 65.4]), with neck trauma being the most common traumatic indication (n = 7, 14.3% [6.4 to 27.9]).

Conclusion: Rescue surgical airways occurred infrequently in the ED (0.28% [0.21 to 0.37]), with approximately half performed due to a trauma indication. These results may have implications for surgical airway skill acquisition, maintenance, and experience.

Pediatric trauma surgery in Iraq and Afghanistan: Mortality, indicators, and most common operating room interventions from 2007 to 2016

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J Trauma Acute Care Surg. 2023 Aug 1;95(2S Suppl 1):S66-S71.

Background: The wars in Afghanistan and Iraq produced thousands of pediatric casualties, using substantial military medical resources. We sought to describe characteristics of pediatric casualties who underwent operative intervention in Iraq and Afghanistan.

Methods: This is a retrospective analysis of pediatric casualties treated by US Forces in the Department of Defense Trauma Registry with at least one operative intervention during their course. We report descriptive, inferential statistics, and multivariable modeling to assess associations for receiving an operative intervention and survival. We excluded casualties who died on arrival to the emergency department.

Results: During the study period, there were a total of 3,439 children in the Department of Defense Trauma Registry, of which 3,388 met inclusion criteria. Of those, 2,538 (75%) required at least 1 operative intervention totaling 13,824 (median, 4; interquartile range, 2-7; range, 1-57). Compared with nonoperative casualties, operative casualties were older and male and had a higher proportion of explosive and firearm injuries, higher median composite injury severity scores, higher overall blood product administration, and longer intensive care hospitalizations. The most common operative procedures were related to abdominal, musculoskeletal, and neurosurgical trauma; burn management; and head and neck. When adjusting for confounders, older age (unit odds ratio, 1.04; 1.02-1.06), receiving a massive transfusion during their initial 24 hours (6.86, 4.43-10.62), explosive injuries (1.43, 1.17-1.81), firearm injuries (1.94, 1.47-2.55), and age-adjusted tachycardia (1.45, 1.20-1.75) were all associated with going to the operating room. Survival to discharge on initial hospitalization was higher in the operative cohort (95% vs. 82%, $p < 0.001$). When adjusting for confounders, operative intervention was associated with improved mortality (odds ratio, 7.43; 5.15-10.72).

Conclusion: Most children treated in US military/coalition treatment facilities required at least one operative intervention. Several preoperative descriptors were associated with casualties' likelihood of operative interventions. Operative management was associated with improved mortality.

Prehospital ventilation targets in severe traumatic brain injury

Theresa Mariero Olasveengen, Nino Stocchetti

Intensive Care Med. 2023 May;49(5):554-555.

No abstract available

Prehospital tranexamic acid for trauma victims

Kazuhiko Omori, Ian Roberts

J Intensive Care. 2023 Mar 22;11(1):12.

Abstract

The public enquiry into the mass casualty incident at the Manchester Arena in the UK in which 23 people died and over 1000 were injured, identified the need for timely intramuscular administration of tranexamic acid to trauma patients. Since then, a number of studies and trials have been carried out and UK paramedics are now authorized to give intramuscular tranexamic acid in the pre-hospital setting. In Japan, pre-hospital administration by emergency life-saving technicians is not yet authorized, despite the fact that tranexamic acid was invented by Japanese scientists. In Japan, the need for the pre-hospital administration of tranexamic acid has been raised on several occasions, where a patient died from traumatic bleeding prior to hospital admission. This paper summarizes the evidence on the use of tranexamic acid in patients with traumatic bleeding, including new evidence on the intramuscular route.

Burn injuries in US service members: 2001-2018

Katheryne G Perez, Susan L Eskridge, Mary C Clouser, Jill M Cancio, Leopoldo C Cancio, Michael R Galarneau

Burns. 2023 Mar;49(2):461-466.

Introduction: Burns are an important cause of battlefield injury, accounting for 5-20% of the combat injury burden. To date, no report has examined the full range of burns, from mild to severe, resulting from post-9/11 conflicts. The present study leverages the Expeditionary Medical Encounter Database (EMED), a Navy-maintained health database describing all service member medical encounters occurring during deployment, to capture, quantify and characterize burn-injured service members and the injuries they sustained while deployed in support of post-9/11 operations.

Methods: The EMED was queried for all surviving service members with at least one burn injury, identified using injury-specific Abbreviated Injury Scale codes. Demographic and additional injury information were also obtained from the EMED.

Results: From 2001 through 2018, 2507 deployed service members sustained 5551 burns. Blasts accounted for 82% of injuries, largely attributed to the use of improvised explosive devices. Concurrent injury was common, with 30% sustaining a traumatic brain injury and 10% sustaining inhalation injury. Most burns were small, with 92% involving< 20% TBSA; 85% of burns involved< 10% TBSA. The head and the hands were the most commonly affected areas, accounting for 48% of all burns, with 80% of service members sustaining at least one burn to these areas.

Conclusion: The majority of burns tend to be small in size, with the head and hands most commonly affected. As these areas are often left uncovered by the uniform, prevention measures, particularly improvement in and increased usage of personal protective gear, may help reduce these injuries and their consequences.

Inhalation Injury: Which Providers Can Assess the Need for Intubation?

Louis Perkins, Henry Horita, Laura Adams, William Marshall, Jeanne Lee, Jay Doucet, Alan Smith, Jarrett E Santorelli

J Burn Care Res. 2023 Jul 5;44(4):785-790.

Abstract

Previous studies have suggested that many burn patients undergo unnecessary intubation due to concern for inhalation injury. We hypothesized that burn surgeons would intubate burn patients at a lower rate than non-burn acute care surgeons (ACSs). We performed a retrospective cohort study of all patients admitted to an American Burn Association-verified burn center who presented emergently following burn injury from June 2015 to December 2021. Patients excluded include polytrauma patients, isolated friction burns, and patients intubated prior to hospital arrival. Our primary outcome was intubation rates between burn and non-burn ACSs. 388 patients met inclusion criteria. 240 (62%) patients were evaluated by a burn provider and 148 (38%) were evaluated by a non-burn provider; the groups were well-matched. In total, 73 (19%) of patients underwent intubation. There was no difference in the rate of emergent intubation, diagnosis of inhalation injury on bronchoscopy, time to extubation, or incidence of extubation within 48 hours between burn and non-burn ACSs. We found no difference between burn and non-burn ACSs in the airway evaluation and management of burn patients. Surgical providers with acute care surgery backgrounds and Advanced Trauma Life Support training are well-equipped for initial airway management in burn patients. Further studies should seek to compare other types of provider groups to identify opportunities for intervention and education in preventing unnecessary intubations.

Retrospective analysis of tranexamic acid administration in French war-wounded between October 2016 and September 2020

Thibault Pinna, N Py, L Aigle, S Travers, P Pasquier, N Cazes

BMJ Mil Health. 2023 Jan 30: Online ahead of print.

Introduction: Since 2013, the French Army Health Service, in agreement with international experts, has recommended the administration of 1 g of tranexamic acid (TXA) in trauma patients in haemorrhagic shock or at risk of bleeding within 3 hours of the trauma.

Methods: The aim of this analysis was to describe the administration of TXA in French military personnel wounded during military operations in the Sahelo-Sahelian band between October 2016 and September 2020. Data were collected from forward health records and hospital data from the French hospital where the casualty was finally evacuated. Underuse of TXA was defined as the lack of administration in casualties who had received a blood transfusion with one or more of red blood cells, low-titre whole blood or French lyophilised plasma within the first 24 hours of injury and overuse as its administration in the non-transfused casualty.

Results: Of the 76 patients included, 75 were men with an average age of 28 years. Five patients died during their management. 19 patients received TXA (25%) and 16 patients were transfused (21%). Underuse of TXA occurred in 3 of the 16 patients (18.8%) transfused. Overuse occurred in 6 of 60 (10%) non-transfused patients.

Conclusion: The analysis found an important underuse of TXA (almost 20%) and highlighted the need for optimising the prehospital clinical practice guidelines to aid prehospital medical practitioners more accurately in administering TXA to casualties that will require blood products.

Dried plasma: An urgent priority for trauma readiness

Travis M Polk, Jennifer M Gurney, Leslie E Riggs, Jeremy W Cannon, Andrew P Cap, Paul A Friedrichs

J Trauma Acute Care Surg. 2023 Aug 1;95(2S Suppl 1):S4-S6.

No abstract available

Intravenous Tranexamic Acid Given at Femoral Fragility Fracture Surgery Reduces Blood Transfusion Requirements Fourfold

Matilda F R Powell-Bowns, Rhys K Olley, Conor McCann, James R Balfour, Caitlin M Brennan, Jasmine Peh, Andrew D Duckworth, Chloe E H Scott

World J Surg. 2023 Apr;47(4):912-921.

Aims: This study aims to determine whether intraoperative intravenous (IV) tranexamic acid (TXA) affects blood loss following the surgical management of femoral fragility fractures (FFF).

Methods: This was a single centre (university teaching hospital) non-randomised case-control study. There were 361 consecutive patients with FFF admitted over a 4-month period were included (mean age 81.4yrs; mean BMI 23.5; 73.7% female). Patient demographics, comorbidities, preoperative anticoagulation use, surgical management, intravenous TXA use, perioperative haemoglobin (Hb) and haematocrit, and requirement for blood transfusion were recorded. The primary outcome was postoperative blood transfusion requirement. Secondary outcomes included postoperative day one calculated blood loss (CBL) (using the Nadler and Gross formulae) and fall in Hb (percentage) from preoperative levels; and the incidence of thrombotic events and mortality up to 30 days.

Results: Groups were well matched in terms of patient demographics, comorbidities, preoperative anticoagulation use, injury types and surgical management. Intravenous TXA 1 g given at the beginning of surgery at the discretion of the operating team: 178 (49%) received TXA and 183 (51%) did not. The requirement for postoperative blood transfusion was significantly less in the TXA group: 15/178 (8.4%) compared to 58/183 (31.7%) ($p < 0.001$; Chi square). TXA significantly reduced both the percentage fall in Hb (mean difference 4.3%, $p < 0.001$) and the CBL (mean difference -222 ml, $p < 0.001$). There was no difference in VTE (2 vs 1, $p = 0.620$) or other thrombotic events (2 vs 0, $p = 0.244$) between groups.

Conclusion: 1 g of intraoperative intravenous TXA during the surgical management of FFF was associated with reduced rate of transfusion, CBL and the percentage drop in HB. The use of TXA in this study was not randomised, so there could be un-quantifiable bias in the patient selection.

Prehospital tourniquet use in civilian extremity trauma: an Australian observational study

David J Read, Jessica Wong, Raine Liu, Kellie Gumm, David Anderson

ANZ J Surg. 2023 Jul-Aug;93(7-8):1896-1900.

Background: Prehospital tourniquets (PHTQ) for trauma have been shown to be safe and effective in the military environment and in some civilian settings. However, the supporting civilian data are mostly from North America with a differing case mix and trauma system and may not be applicable to the Australian environment. The aim of this study is to describe our initial experience with PHTQ from safety and efficacy viewpoints.

Method: Retrospective review of all patients with PHTQ from 1 August 2016 to 31 December 2019 was conducted. Data were matched from the RMH Trauma Registry and Ambulance Victoria Registry. Clinical presentation including prehospital observations, PHTQ times, limb outcomes and complications are described.

Results: Thirty-one cases met inclusion criteria, for whom median age was 37 (IQR: 23.9-66.3), median ISS 17 (13-34) and 80.6% were male. The majority (n = 19, 61.3%) were as a result of road traffic crash, and six (19.4%) from penetrating mechanisms, usually glass. Over a quarter (29.0%) suffered a traumatic amputation. The median prehospital SBP was 100 (IQR: 80-110), the median prehospital HR was 101 (IQR: 77.0-122.3) and was the median PHTQ time was 124 min (IQR: 47-243). Complications attributable to the tourniquet were seen in 4/30 cases (13.3%).

Conclusion: This Australian series differs from North American civilian PHTQ series with a lower penetrating trauma rate and longer PHTQ times. Despite this, complication rates are within the published literature's range. Concerns regarding limited transferability of overseas studies to the Australian context suggests that ongoing audit is required.

Narrative Review: Low-Dose Ketamine for Pain Management

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J Clin Med. 2023 May 2;12(9):3256.

Abstract

Pain is the leading cause of medical consultations and occurs in 50-70% of emergency department visits. To date, several drugs have been used to manage pain. The clinical use of ketamine began in the 1960s and it immediately emerged as a manageable and safe drug for sedation and anesthesia. The analgesic properties of this drug were first reported shortly after its use; however, its psychomimetic effects have limited its use in emergency departments. Owing to the misuse and abuse of opioids in some countries worldwide, ketamine has become a versatile tool for sedation and analgesia. In this narrative review, ketamine's role as an analgesic is discussed, with both known and new applications in various contexts (acute, chronic, and neuropathic pain), along with its strengths and weaknesses, especially in terms of psychomimetic, cardiovascular, and hepatic effects. Moreover, new scientific evidence has been reviewed on the use of additional drugs with ketamine, such as magnesium infusion for improving analgesia and clonidine for treating psychomimetic symptoms. Finally, this narrative review was refined by the experience of the Pain Group of the Italian Society of Emergency Medicine (SIMEU) in treating acute and chronic pain with acute manifestations in Italian Emergency Departments.

A Comparison of Combat Casualty Outcomes after Prehospital Versus Military Treatment Facility Airway Management

Steven G Schauer, Michael D April

Med J (Ft Sam Houst Tex). 2023 Jan-Mar:(Per 23-1/2/3):92-96.

Background: Airway obstruction is the second leading cause of potentially survivable death on the battlefield. Previous studies demonstrate casualties undergoing airway interventions have worse outcomes when the procedure occurs in the prehospital setting versus the military treatment facility (MTF) setting. We compare outcomes between casualties undergoing airway management in these 2 settings using the Department of Defense Trauma Registry (DODTR).

Methods: This is a secondary analysis of a previously described dataset from the DODTR. We included US military casualties with at least 24 hours on the ventilator. We compared casualties who underwent intubation in the prehospital setting versus hospital setting. Multivariable logistic regression models were constructed to adjust for available confounders.

Results: There were 2,124 that met inclusion for this analysis-278 in the prehospital cohort and 1,846 in the MTF cohort. Median injury severity scores were higher in the prehospital cohort (25 versus 22, p is less than 0.001). The survival to discharge was lower in the prehospital cohort (80% versus 93%, p is less than 0.001). On multivariable logistic regression model, when adjusting for injury severity score, mechanism of injury, and first 24-hour blood products, the odds of survival were 0.34 (95% CI 0.23-0.50) for those intubated prehospital versus MTF.

Conclusions: We found worse survival for those with prehospital airway intervention versus those in the MTF setting. These findings persisted after adjustment for measurable confounders. Our findings suggest prehospital-focused improvements in airway interventions are needed and/or robust methods for rapid evacuation to an MTF for airway intervention.

A prospective assessment of the medic autologous blood transfusion skills for field transfusion preparation

Steven G Schauer, Fabiola Mancha, Jessica Mendez, Melody A Martinez, Erika A Jeschke, Michael D April, Andrew D Fisher, Derek J Brown, Wells L Weymouth, Jason B Corley, Ronnie Hill, Andrew P Cap

Transfusion. 2023 May:63 Suppl 3:S67-S76. doi: 10.1111/trf.17325. Epub 2023 Apr 17.

Background: Data demonstrate the benefit of blood product administration near point-of-injury (POI). Fresh whole blood transfusion from a pre-screened donor provides a source of blood at the POI when resources are constrained. We captured transfusion skills data for medics performing autologous blood transfusion training.

Methods: We conducted a prospective, observational study of medics with varying levels of experience. Inexperienced medics were those with minimal or no reported experience learning the autologous transfusion procedures, versus reported experience among special operations medics. When available, medics were debriefed after the procedure for qualitative feedback. We followed them for up to 7 days for adverse events.

Results: The median number of attempts for inexperienced and experienced medics was 1 versus 1 (interquartile range 1-1 for both, $p = .260$). The inexperienced medics had a slower median time to needle venipuncture access for the donation of 7.3 versus 1.5 min, needle removal after clamping time of 0.3 versus 0.2 min, time to bag preparation of 1.9 versus 1.0 min, time to IV access for reinfusion of 6.0 versus 3.0 min, time to transfusion completion of 17.3 versus 11.0 min, and time to IV removal of 0.9 versus 0.3 min (all $p < .05$). We noted one administrative safety event in which an allogeneic transfusion occurred. No major adverse events occurred. Qualitative data saturated around the need for quarterly training.

Conclusions: Inexperienced medics have longer procedure times when training autologous whole blood transfusion skills. This data will help establish training measures of performance for skills optimization when learning this procedure.

Improving Outcomes Associated with Prehospital Combat Airway Interventions: An Unrealized Opportunity

Steven G Schauer, Ian L Hudson, Andrew D Fisher, Gregory Dion, Brit Long, Megan B Blackburn, Robert A De Lorenzo, Travis A Shaw, Michael D April

J Spec Oper Med. 2023 Mar 15;23(1):23-29.

Background: Airway obstruction is the second leading cause of potentially survivable death on the battlefield. Assessing outcomes associated with airway interventions is important, and temporal trends can reflect the influence of training, technology, the system of care, and other factors. We assessed mortality among casualties undergoing prehospital airway intervention occurring over the course of combat operations during 2007-2019.

Methods: This is a retrospective analysis of a previously described dataset from the Department of Defense Trauma Registry (DODTR). We included only casualties with documented placement of an endotracheal tube, cricothyrotomy, or supraglottic airway (SGA) in the prehospital setting.

Results: Within the DODTR from January 2007 to December 2019, there were 25,849 adult encounters with documentation of any prehospital activity. Within that group, there were 251 documented cricothyrotomies, 1,147 documented intubations, and 35 documented supraglottic airways placed. Cricothyrotomy recipients had a median age of 25. Within this group, the largest proportion were non-North Atlantic Treaty Organization (NATO) military personnel (35%), were injured by explosives (54%), had a median injury severity score (ISS) of 24, and 60% survived to hospital discharge. Intubation recipients had a median age of 24. Within this group, the largest proportion were non-NATO military personnel (37%), were injured by explosives (57%), had a median ISS of 18, and 76% survived to hospital discharge. SGA recipients had a median age of 28. Within this group, the largest proportion were non-NATO military (37%), were injured by firearms (48%), had a median ISS of 25, and 54% survived to hospital discharge. A downward trend existed in the quantity of all procedures performed during the study period. In both unadjusted and adjusted regression models, we identified no year-to-year differences in survival after prehospital cricothyrotomy or SGA placement. In the unadjusted and adjusted models, we noted a decrease in mortality during the 2007-2008 (odds ratio [OR] for death 0.47, 95% CI 0.26-0.86) and an increase from 2012-2013 (OR 2.10, 95% CI 1.09-4.05) for prehospital intubation.

Conclusion: Mortality among combat casualties undergoing prehospital or emergency department airway interventions showed no sustained change during the study period. These findings suggest that advances in airway resuscitation are necessary to achieve mortality improvements in potentially survivable airway injuries in the prehospital setting.

Increasing use of prehospital mechanical ventilation by emergency medical services (EMS)

Aditya C Shekhar, Ira J Blumen, Keith J Ruskin

No abstract available

A Systematic Review of Prehospital Combat Airway Management

Shane Smith, Michael Liu, Ian Ball, Bethann Meunier, Richard Hilsden

J Spec Oper Med. 2023 Mar 15;23(1):31-37.

Abstract

Medical leadership must decide how prehospital airways will be managed in a combat environment, and airway skills can be complicated and difficult to learn. Evidence informed airway strategies are essential. A search was conducted in Medline and EMBASE databases for prehospital combat airway use. The primary data of interest was what type of airway was used. Other data reviewed included: who performed the intervention and the success rate of the intervention. The search strategy produced 2,624 results, of which 18 were included in the final analysis. Endotracheal intubation, cricothyroidotomy, supraglottic airways, and nasopharyngeal airways have all been used in the prehospital combat environment. This review summarizes the entirety of the available combat literature such that commanders may make an evidence-based informed decision with respect to their airway management policies.

Whole Blood Resuscitation and Association with Survival in Injured Patients with an Elevated Probability of Mortality

Jason L Sperry, Bryan A Cotton, James F Luther, Jeremy W Cannon, Martin A Schreiber, Ernest E Moore, Nicholas Namias, Joseph P Minei, Stephen R Wisniewski, Frank X Guyette; Shock, Whole Blood, and Assessment of Traumatic Brain Injury (SWAT) Study Group

J Am Coll Surg. 2023 Aug 1;237(2):206-219.

Background: Low-titer group O whole blood (LTOWB) resuscitation is becoming common in both military and civilian settings and may represent the ideal resuscitation intervention. We sought to characterize the safety and efficacy of LTOWB resuscitation relative to blood component resuscitation.

Study design: A prospective, multicenter, observational cohort study was performed using 7 trauma centers. Injured patients at risk of massive transfusion who required both blood transfusion and hemorrhage control procedures were enrolled. The primary outcome was 4-hour mortality. Secondary outcomes included 24-hour and 28-day mortality, achievement of hemostasis, death from exsanguination, and the incidence of unexpected survivors.

Results: A total of 1,051 patients in hemorrhagic shock met all enrollment criteria. The cohort was severely injured with >70% of patients requiring massive transfusion. After propensity adjustment, no significant 4-hour mortality difference across LTOWB and component patients was found (relative risk [RR] 0.90, 95% CI 0.59 to 1.39, p = 0.64). Similarly, no adjusted mortality differences were demonstrated at 24 hours or 28 days for the enrolled cohort. When patients with an elevated prehospital probability of mortality were analyzed, LTOWB resuscitation was independently associated with a 48% lower risk of 4-hour mortality (relative risk [RR] 0.52, 95% CI 0.32 to 0.87, p = 0.01) and a 30% lower risk of 28-day mortality (RR 0.70, 95% CI 0.51 to 0.96, p = 0.03).

Conclusions: Early LTOWB resuscitation is safe but not independently associated with survival for the overall enrolled population. When patients were selected with an elevated probability of mortality based on prehospital injury characteristics, LTOWB was independently associated with a lower risk of mortality starting at 4 hours after arrival through 28 days after injury.

In vitro comparison of cold-stored whole blood and reconstituted whole blood

Sanna Susila, Tuukka Helin, Jouni Lauronen, Lotta Joutsi-Korhonen, Minna Ilmakunnas

Vox Sang. 2023 Jul;118(7):523-532.

Background and objectives: Cold-stored whole blood (CSWB) is increasingly used in damage control resuscitation. Haemostatic function of CSWB seems superior to that of reconstituted whole blood, and it is sufficiently preserved for 14-21 days. To provide evidence for a yet insufficiently studied aspect of prehospital CSWB use, we compared in vitro haemostatic properties of CSWB and currently used in-hospital and prehospital blood component therapies.

Materials and methods: Blood was obtained from 24 O RhD positive male donors. Three products were prepared: CSWB, in-hospital component therapy (red blood cells [RBCs], OctaplasLG and platelets 1:1:1) and prehospital component therapy (RBCs and lyophilized plasma 1:1). Samples were drawn on days 1 and 14 of CSWB or RBC cold storage. On day 14, platelet concentrates at their expiry (5 days) were used for 1:1:1 mixing. Conventional clotting assays, rotational thromboelastometry, thrombin formation and platelet function were assessed.

Results: Haemoglobin, platelet count, fibrinogen and coagulation factor levels remained closest to physiological in CSWB. Factor VIII activity decreased markedly by day 14 in CSWB. The decline in platelet function was prominent in CSWB. However, CSWB on day 14 yielded physiological EXTEM MCF, suggesting haemostatically sufficient platelet function. Despite haemodilution and lower coagulation factor levels, in-hospital component therapy was haemostatically adequate. Prehospital component therapy formed the weakest clots. Thrombin formation potential remained comparable and stable in all groups.

Conclusion: Current prehospital component therapy fails to offer the clotting potential that CSWB does. CSWB and current in-hospital 1:1:1 component therapy show similar haemostatic potential until 14 days of storage.

Risk of Harm in Needle Decompression for Tension Pneumothorax

Patrick Thompson, Angelo Ciaraglia, Erin Handspiker, Christopher Bjerkvig, James A Bynum, Elon Glassberg, Jennifer M Gurney, Anthony J Hudson, Donald H Jenkins, Susannah E Nicholson, Geir Strandenes, Maxwell A Braverman

J Spec Oper Med. 2023 Jun 23;23(2):9-12.

Introduction: Tension pneumothorax (TPX) is the third most common cause of preventable death in trauma. Needle decompression at the fifth intercostal space at anterior axillary line (5th ICS AAL) is recommended by Tactical Combat Casualty Care (TCCC) with an 83-mm needle catheter unit (NCU). We sought to determine the risk of cardiac injury at this site.

Methods: Institutional data sets from two trauma centers were queried for 200 patients with CT chest. Inclusion criteria include body mass index of =30 and age 18-40 years. Measurements were taken at 2nd ICS mid clavicular line (MCL), 5th ICS AAL and distance from the skin to pericardium at 5th ICS AAL. Groups were compared using Mann-Whitney U and chi-squared tests.

Results: The median age was 27 years with median BMI of 23.8 kg/m2. The cohort was 69.5% male. Mean chest wall thickness at 2nd ICS MCL was 38-mm (interquartile range (IQR) 32-45). At 5th ICS AAL, the median chest wall thickness was 30-mm (IQR 21-40) and the distance from skin to pericardium was 66-mm (IQR 54-79).

Conclusion: The distance from skin to pericardium for 75% of patients falls within the length of the recommended needle catheter unit (83-mm). The current TCCC recommendation to "hub" the 83mm needle catheter unit has potential risk of cardiac injury.

External Hemorrhage Control Techniques for Human Space Exploration: Lessons from the Battlefield

Stijn J J Thoolen, Maybritt I Kuypers

Wilderness Environ Med. 2023 Jun;34(2):231-242.

Abstract

The past few decades of military experience have brought major advances in the prehospital care of patients with trauma. A focus on early hemorrhage control with aggressive use of tourniquets and hemostatic gauze is now generally accepted. This narrative literature review aims to discuss external hemorrhage control and the applicability of military concepts in space exploration. In space, environmental hazards, spacesuit removal, and limited crew training could cause significant time delays in providing initial trauma care. Cardiovascular and hematological adaptations to the microgravity environment are likely to reduce the ability to compensate, and resources for advanced resuscitation are limited. Any unscheduled emergency evacuation requires a patient to don a spacesuit, involves exposure to high G-forces upon re-entry into Earth's atmosphere, and costs a significant amount of time until a definitive care facility is reached. As a result, early hemorrhage control in space is critical. Safe implementation of hemostatic dressings and tourniquets seems feasible, but adequate training will be essential, and tourniquets are preferably converted to other methods of hemostasis in case of a prolonged medical evacuation. Other emerging approaches such as early tranexamic acid administration and more advanced techniques have shown promising results as well. For future exploration missions to the Moon and Mars, when evacuation is not possible, we look into what training or assistance tools would be helpful in managing the bleed at the point of injury.

Airway Management During the Last 100 Years

Sonia Vaida, Luis Gaitini, Mostafa Somri, Ibrahim Matter, Jansie Prozesky

Crit Care Clin. 2023 Jul;39(3):451-464

Abstract

A large variety of airway devices, techniques, and cognitive tools have been developed during the last 100 years to improve airway management safety and became a topic of major research interest. This article reviews the main developments in this period, starting with modern day laryngoscopy in the 1940s, fiberoptic laryngoscopy in the 1960s, supraglottic airway devices in the 1980s, algorithms for difficult airway in the 1990s, and finally modern video-laryngoscopy in the 2000s.

The effectiveness of Foley catheter balloon tamponade versus expanding sponges and hemostatic granules for catastrophic penetrating groin hemorrhage with small skin defect: A comparative study in a live tissue porcine model with evaluation of a concise training program

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J Trauma Acute Care Surg. 2023 Apr 1;94(4):599-607.

Background: Prompt bleeding control in the prehospital phase is essential to improve survival from catastrophic junctional hemorrhage. This study aimed to compare the effectiveness and practicality of Foley catheter balloon tamponade (FCBT), Celox-A, and XSTAT for the treatment of catastrophic hemorrhage from penetrating groin injuries with a small skin defect in a live-tissue porcine model. In addition, this study aimed to determine whether a training program could train military personnel in application of these advanced bleeding control adjuncts.

Methods: A standardized wound was created in 18 groins from 9 anesthetized swine. Eighteen military medics participated in the training program and performed a bleeding control procedure after randomization over the swine and test products and after transection of the femoral neurovascular bundle. Primary endpoints were bleeding control, time to bleeding control, rebleeding, blood loss, medic performance, and user product rating.

Results: No significant differences were found in vital signs and laboratory values between the groups. In the Celox-A group, 3/6 groins achieved hemorrhage control. This was 6/6 in the XSTAT and FCBT groups. XSTAT scored best on application time, time to obtain hemorrhage control, hemorrhage control score, and practicality. No significant differences were found between groups for rebleeding, amount of blood loss, and medic performance. Military medics had a significant higher preference for XSTAT over Celox-A. This was not significant for FCBT.

Conclusion: All tested products proved effective in obtaining hemorrhage control. XSTAT has the highest effectivity and shortest application time for the treatment of catastrophic bleeding from nonpackable, penetrating junctional groin injuries with a small skin defect, compared with Celox-A and FCBT. XSTAT scored best on practicality. This study shows that our training curriculum can be used to train military medics with limited prior experience in the use of advanced bleeding control techniques for penetrating junctional groin injuries with small skin defect.

Comparing the Effects of Low-Dose Ketamine, Fentanyl, and Morphine on Hemorrhagic Tolerance and Analgesia in Humans

Joseph Charles Watso, Mu Huang, Joseph Maxwell Hendrix, Luke Norman Belval, Gilbert Moralez, Matthew Nathaniel Cramer, Josh Foster, Carmen Hinojosa-Laborde, Craig Gerald Crandall

Prehosp Emerg Care. 2023;27(5):600-612.

Abstract

Hemorrhage is a leading cause of preventable battlefield and civilian trauma deaths. Ketamine, fentanyl, and morphine are recommended analgesics for use in the prehospital (i.e., field) setting to reduce pain. However, it is unknown whether any of these analgesics reduce hemorrhagic tolerance in humans. We tested the hypothesis that fentanyl (75 µg) and morphine (5 mg), but not ketamine (20 mg), would reduce tolerance to simulated hemorrhage in conscious humans. Each of the three analgesics was evaluated independently among different cohorts of healthy adults in a randomized, crossover (within drug/placebo comparison), placebo-controlled fashion using doses derived from the Tactical Combat Casualty Care Guidelines for Medical Personnel. One minute after an intravenous infusion of the analgesic or placebo (saline), we employed a pre-syncopal limited progressive lower-body negative pressure (LBNP) protocol to determine hemorrhagic tolerance. Hemorrhagic tolerance was quantified as a cumulative stress index (CSI), which is the sum of products of the LBNP and the duration (e.g., [40 mmHg x 3 min] + [50 mmHg x 3 min] …). Compared with ketamine ($p = 0.002$ post hoc result) and fentanyl ($p = 0.02$ post hoc result), morphine reduced the CSI (ketamine ($n = 30$): 99 [73-139], fentanyl ($n = 28$): 95 [68-130], morphine ($n = 30$): 62 [35-85]; values expressed as a % of the respective placebo trial's CSI; median [IQR]; Kruskal-Wallis test $p = 0.002$). Morphine-induced reductions in tolerance to central hypovolemia were not well explained by a prediction model including biological sex, body mass, and age ($R2=0.05$, $p = 0.74$). These experimental data demonstrate that morphine reduces tolerance to simulated hemorrhage while fentanyl and ketamine do not affect tolerance. Thus, these laboratory-based data, captured via simulated hemorrhage, suggest that morphine should not be used for a hemorrhaging individual in the prehospital setting.

Management of traumatic brain injury in the non-neurosurgical intensive care unit: a narrative review of current evidence

M D Wiles, M Braganza, H Edwards, E Krause, J Jackson, F Tait

Anaesthesia. 2023 Apr;78(4):510-520.

Abstract

Each year, approximately 70 million people suffer traumatic brain injury, which has a significant physical, psychosocial and economic impact for patients and their families. It is recommended in the UK that all patients with traumatic brain injury and a Glasgow coma scale ≤ 8 should be transferred to a neurosurgical centre. However, many patients, especially those in whom neurosurgery is not required, are not treated in, nor transferred to, a neurosurgical centre. This review aims to provide clinicians who work in non-neurosurgical centres with a summary of contemporary studies relevant to the critical care management of patients with traumatic brain injury. A targeted literature review was undertaken that included guidelines, systematic reviews, meta-analyses, clinical trials and randomised controlled trials (published in English between 1 January 2017 and 1 July 2022). Studies involving key clinical management strategies published before this time, but which have not been updated or repeated, were also eligible for inclusion. Analysis of the topics identified during the review was then summarised. These included: fundamental critical care management approaches (including ventilation strategies, fluid management, seizure control and osmotherapy); use of processed electroencephalogram monitoring; non-invasive assessment of intracranial pressure; prognostication; and rehabilitation techniques. Through this process, we have formulated practical recommendations to guide clinical practice in non-specialist centres.

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Abstract

Each year, approximately 70 million people suffer traumatic brain injury, which has a significant physical, psychosocial and economic impact for patients and their families. It is recommended in the UK that all patients with traumatic brain injury and a Glasgow coma scale ≤ 8 should be transferred to a neurosurgical centre. However, many patients, especially those in whom neurosurgery is not required, are not treated in, nor transferred to, a neurosurgical centre. This review aims to provide clinicians who work in non-neurosurgical centres with a summary of contemporary studies relevant to the critical care management of patients with traumatic brain injury. A targeted literature review was undertaken that included guidelines, systematic reviews, meta-analyses, clinical trials and randomised controlled trials (published in English between 1 January 2017 and 1 July 2022). Studies involving key clinical management strategies published before this time, but which have not been updated or repeated, were also eligible for inclusion. Analysis of the topics identified during the review was then summarised. These included: fundamental critical care management approaches (including ventilation strategies, fluid management, seizure control and osmotherapy); use of processed electroencephalogram monitoring; non-invasive assessment of intracranial pressure; prognostication; and rehabilitation techniques. Through this process, we have formulated practical recommendations to guide clinical practice in non-specialist centres.

Efficacy and safety of tranexamic acid in intracranial haemorrhage: A meta-analysis

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PLoS One. 2023 Mar 31;18(3):e0282726.

Background: Although some studies have shown that tranexamic acid is beneficial to patients with intracranial haemorrhage, the efficacy and safety of tranexamic acid for intracranial haemorrhage remain controversial.

Method: The PubMed, EMBASE, and Cochrane Library databases were systematically searched. The review followed PRISMA guidelines. Data were analyzed using the random-effects model.

Results: Twenty-five randomized controlled trials were included. Tranexamic acid significantly inhibited hematoma growth in intracranial hemorrhage (ICH) and traumatic brain injury (TBI) patients. (ICH: mean difference -1.76, 95%CI -2.78 to -0.79, I2 = 0%, P < .001; TBI: MD -4.82, 95%CI -8.06 to -1.58, I2 = 0%, P = .004). For subarachnoid hemorrhage (SAH) patients, it significantly decreased the risk of hydrocephalus (OR 1.23, 95%CI 1.01 to 1.50, I2 = 0%, P = .04) and rebleeding (OR, 0.52, 95%CI 0.35 to 0.79, I2 = 56% P = .002). There was no significance in modified Rankin Scale, Glasgow Outcome Scale 3-5, mortality, deep vein thrombosis, pulmonary embolism, or ischemic stroke/transient ischemic.

Conclusion: Tranexamic acid can significantly reduce the risk of intracranial haemorrhage growth in patients with ICH and TBI. Tranexamic acid can reduce the incidence of complications (hydrocephalus, rebleeding) in patients with SAH, which can indirectly improve the quality of life of patients with intracranial haemorrhage.

Blast-Related Traumatic Brain Injuries Secondary to Thermobaric Explosives: Implications for the War in Ukraine

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World Neurosurg. 2022 Nov:167:176-183.

Abstract

Blast-related traumatic brain injury (bTBI) is a significant cause of wartime morbidity and mortality. In recent decades, thermobaric explosives have emerged as particularly devastating weapons associated with bTBI. With recent documentation of the use of these weapons in the war in Ukraine, clinicians and laypersons alike could benefit from an improved understanding behind the dynamic interplay between explosive weaponry, its potential for bTBI, and the subsequent long-term consequences of these injuries. Therefore, we provide a general overview of the history and mechanism of action of thermobaric weapons and their potential to cause bTBI. In addition, we highlight the long-term cognitive and neuropsychiatric sequelae following bTBI and discuss diagnostic, therapeutic, and rehabilitation strategies, with the aim of helping to guide mitigation strategies and humanitarian relief in Ukraine. Thermobaric weapons produce a powerful blast wave capable of causing bTBIs, which can be further classified from primary to quaternary injuries. When modeling the hypothetical use of thermobaric weapons in Odessa, Ukraine, we estimate that the detonation of a salvo of thermobaric rockets has the potential to affect approximately 272 persons with bTBIs. In addition to the short-term damage, patients with bTBIs can present with long-term symptoms (e.g., post-traumatic stress disorder), which incur substantial financial costs and social consequences. Although these results are jarring, history has seen radical advancements in the understanding, diagnosis, and management of bTBI. Moving forward, a better understanding of the mechanism and long-term sequelae of bTBIs could help guide humanitarian relief to those affected by the war in Ukraine.

Effect of SAM junctional tourniquet on respiration when applied in the axilla: A swine model

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Chin J Traumatol. 2023 May;26(3):131-138.

Purpose: SAM junctional tourniquet (SJT) has been applied to control junctional hemorrhage. However, there is limited information about its safety and efficacy when applied in the axilla. This study aims to investigate the effect of SJT on respiration when used in the axilla in a swine model.

Methods: Eighteen male Yorkshire swines, aged 6-month-old and weighing 55 - 72 kg, were randomized into 3 groups, with 6 in each. An axillary hemorrhage model was established by cutting a 2 mm transverse incision in the axillary artery. Hemorrhagic shock was induced by exsanguinating through the left carotid artery to achieve a controlled volume reduction of 30% of total blood volume. Vascular blocking bands were used to temporarily control axillary hemorrhage before SJT was applied. In Group I, the swine spontaneously breathed, while SJT was applied for 2 h with a pressure of 210 mmHg. In Group II, the swine were mechanically ventilated, and SJT was applied for the same duration and pressure as Group I. In Group III, the swine spontaneously breathed, but the axillary hemorrhage was controlled using vascular blocking bands without SJT compression. The amount of free blood loss was calculated in the axillary wound during the 2 h of hemostasis by SJT application or vascular blocking bands. After then, a temporary vascular shunt was performed in the 3 groups to achieve resuscitation. Pathophysiologic state of each swine was monitored for 1 h with an infusion of 400 mL of autologous whole blood and 500 mL of lactated ringer solution. Tb and T0 represent the time points before and immediate after the 30% volume-controlled hemorrhagic shock, respectively. T30, T60, T90 and T120, denote 30, 60, 90, and 120 min after T0 (hemostasis period), while T150, and T180 denote 150 and 180 min after T0 (resuscitation period). The mean arterial pressure and heart rate were monitored through the right carotid artery catheter. Blood samples were collected at each time point for the analysis of blood gas, complete cell count, serum chemistry, standard coagulation tests, etc., and thromboelastography was conducted subsequently. Movement of the left hemidiaphragm was measured by ultrasonography at Tb and T0 to assess respiration. Data were presented as mean ± standard deviation and analyzed using repeated measures of two-way analysis of variance with pairwise comparisons adjusted using the Bonferroni method. All statistical analyses were processed using GraphPad Prism software.

Results: Compared to Tb, a statistically significant increase in the left hemidiaphragm movement at T0 was observed in Groups I and II (both $p < 0.001$). In Group III, the left hemidiaphragm movement remained unchanged ($p = 0.660$). Compared to Group I, mechanical ventilation in Group II significantly alleviated the effect of SJT application on the left hemidiaphragm movement ($p < 0.001$). Blood pressure and heart rate rapidly increased at T0 in all three groups. Respiratory arrest suddenly occurred in Group I after T120, which required immediate manual respiratory assistance. PaO_2 in Group I decreased significantly at T120, accompanied by an increase in $PaCO_2$ (both $p < 0.001$ vs. Groups II and III). Other biochemical metabolic changes were similar among groups. However, in all 3 groups, lactate and potassium increased immediately after 1 min of resuscitation concurrent with a drop in pH. The swine in Group I exhibited the most severe hyperkalemia and metabolic acidosis. The coagulation function test did not show statistically significant differences among three groups at any time point. However, D-dimer levels showed a more than 16-fold increase from T120 to T180 in all groups.

Conclusion: In the swine model, SJT is effective in controlling axillary hemorrhage during both spontaneous breathing and mechanical ventilation. Mechanical ventilation is found to alleviate the restrictive effect of SJT on thoracic movement without affecting hemostatic efficiency. Therefore, mechanical ventilation could be necessary before SJT removal.