Committee on Surgical Combat Casualty Care (CoSCCC)

Journal Watch

1st Quarter

FY 2022

Journal Watch Key Terminology Searched:

Microcirculation	Trauma Management	Haemorrhage
Shock	Sublingual	Ethics committees
Human subject research	IDF	Institutional review board
Haemorrhagic shock	Multiple trauma	Shock index
Traumatic brain injury	Coagulopathy	Diagnostic accuracy
Plasma	Pre-hospital	Thrombelastography (TEG)
Transfusion	Trauma	Imaging
RBCs	Resuscitation	Severe trauma
Stability	Ultrasound	Afghanistan
Blast	Facial trauma	War
Amputation	Multiple	Transfusion
Traumatic Clinical outcomes	Clinical parameters	Damage control Surgery
Injury	Pelvic fracture	Battlefield Trauma
Coagulopathy	Cryoprecipitate	Fibrinogen
Fibrinogen concentrate	Massive transfusion	ABO
Viscoelastic haemostatic assays	Angiography	External fixation
Guidelines	Internal fixation	Pelvic ring
Fractures	X-ray	Pre-peritoneal pelvic packing
REBOA	Antibiotic prophylaxis	Long bone fractures
Orthopaedic trauma	Perioperative antibiotics	Surgical site infection
Wound ballistics	Faecal diversion	Primary repair
Cause of injury	Head injuries	Poly-trauma
Damage Control Resuscitation	Battlefield injury	Prolonged field care
Tension pneumothorax	Thoracotomy	Military Medicine
Blast Injury	Died of Wounds	Killed in Action
Combat casualty care	Medical treatment facility	Mortality
Surgical skills	Emergency surgery	Infection prevention
Novel Coronavirus	COVID-19	Hypocalcemia
Predictions	Vital Signs	Global Surgery
Limb Salvage	Temporary Shunts	

Machine Learning for Military Trauma: Novel Massive Transfusion Predictive Models in Combat Zones

Daniel Lammers [1], Christopher Marenco [2], Kaitlin Morte [2], Jeffrey Conner [2], James Williams [2], Tim Bax [3], Matthew Martin [4], Matthew Eckert [5], Jason Bingham [2]

Abstract

Background: Damage control resuscitation has become the standard of care in military and civilian trauma. Early identification of blood product requirements may aid in optimizing the clinical decision-making process while improving trauma related outcomes. This study aimed to assess and compare multiple machine learning models for predicting patients at highest risk for massive transfusion on the battlefield.

Methods: Supervised machine learning approaches using logistic regression, support vector machine, neural network, and random forest techniques were used to create predictive models for massive transfusion using standard prehospital and arrival data points from the Department of Defense Trauma Registry, 2008-2016. Seventy percent of the population was used for model development and performance was validated using the remaining 30%. Models were tested for accuracy and compared by standard performance statistics.

Results: A total of 22,158 patients (97% male, 58% penetrating injury, median age 25-29 y/o, average Injury Severity Score 9, with an overall mortality of 3%) were included in the analysis. Massive transfusion was required by 7.4% of patients. Overall accuracy was found to be above 90% in all models tested. Following cross validation and model training, the random forest model outperformed the alternatively tested models for precision, recall, and area under the curve.

Conclusion: Machine learning techniques may allow for more optimal and rapid identification of combat trauma patients at highest risk for massive transfusion. These powerful approaches may uncover novel correlations and help improve triage, activation of massive transfusion resources, and trauma-related outcomes. Further research seeking to optimize and apply these algorithms to trauma-centered research should be pursued.

Keywords: Level of Evidence: Level IV; Machine learning; Massive transfusion; Military; Trauma.

Evaluation of hemostatic capacities among commando candidates: Would their blood suit a hemorrhagic war-injured patient in case of blood donation on the battlefield?

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Abstract

Background: In case of a warm fresh whole blood transfusion on the battlefield, the blood donation usually occurs just after a combat phase and often after several days on the fields. To explore the hemostatic capacity of such blood, we analyzed the blood of volunteers attending the commando course of the French Navy, considering this course as an experimental model, placing them into the same physiological conditions as those faced by deployed fighters.

Methods: Venous blood was collected at the beginning of the course, mimicking their baseline status, and a second time 6 weeks later, from the remaining candidates, during the actual commando training, mimicking the stress conditions. For each candidate, we observed the differences between the two blood samples.

Results: Of the 112 men that attended the first day of the course, only 17 remained 6 weeks later. In the second blood samples, we noted significant increased leucocytes and platelets counts and significant decreased hematocrit and hemoglobin levels. Thrombin generation assays showed significantly lower normalized peak heights (-31%), lower normalized endogenous thrombin potential values (-29%), and lower velocity index (-35%). Normalized lag time and time to peak did not differ. Viscoelastometric testing revealed a significant increasing in clot firmness as assessed by maximum amplitude and amplitude at 6 minutes. The clot speed was significantly increased.

Conclusion: This work brings new data on coagulation during prolonged and considerable physical exercise. No obvious deleterious modification of hemostatic properties was observed. The decrease of the endogenous thrombin potentials may reflect a better ability to control the thrombin generation once started. Altogether, these results suggest that this blood could suit well a hemorrhagic war-injured patient.

Level of evidence: Prospective observational cohort study, Level III.

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

Eran Beit Ner [1 2], Avishai M Tsur [1], Roy Nadler [1 3], Elon Glassberg [1 4 5], Avi Benov [1 4], Jacob Chen [1 6]

Abstract

Introduction: Securing the airway is a crucial stage of trauma care. Cricothyroidotomy (CRIC) is often addressed as a salvage procedure in complicated cases or following a failed endotracheal intubation (ETI). Nevertheless, it is a very important skill in prehospital settings, such as on the battlefield.

Hypothesis/problem: This study aimed to review the Israel Defense Forces (IDF) experience with CRIC over the past two decades.

Methods: The IDF Trauma Registry (IDF-TR) holds data on all trauma casualties (civilian and military) cared for by military medical teams since 1997. Data of all casualties treated by IDF from 1998 through 2018 were extracted and analyzed to identify all patients who underwent CRIC procedures.Variables describing the incident scenario, patient's characteristics, injury pattern, treatment, and outcome were extracted. The success rate of the procedure was described, and selected variables were further analyzed and compared using the Fisher's-exact test to identify their effect on the success and failure rates. Odds Ratio (OR) was further calculated for the effect of different body part involvement on success and for the mortality after failed ETI.

Results: One hundred fifty-three casualties on which a CRIC attempt was made were identified from the IDF-TR records. The overall success rate of CRIC was reported at 88%. In patients who underwent one or two attempts, the success rate was 86%. No difference was found across providers (physician versus paramedic). The CRIC success rates for casualties with and without head trauma were 80% and 92%, respectively (P = .06). Overall mortality was 33%.

Conclusions: This study shows that CRIC is of merit in airway management as it has shown to have consistently high success rates throughout different levels of training, injuries, and previous attempts with ETI. Care providers should be encouraged to retain and develop this skill as part of their tool box.

Keywords: airway management; military medicine; registries.

A Descriptive Analysis of Supermassive Transfusion Recipients Among US and Coalition Forces During Combat Operations in Afghanistan and Iraq

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Abstract

Introduction: Hemorrhage is the leading cause of potentially preventable death on the battlefield. Resuscitation with blood products is essential to restore circulating volume, repay the oxygen debt, and prevent coagulopathy. Massive transfusion (MT) occurs frequently after major trauma; a subset of casualties requires a supermassive transfusion (SMT), and thus, mobilization of additional resources remains unclear.

Materials and methods: This is a secondary analysis of a previously described dataset from the Department of Defense Trauma Registry. In this analysis, we isolated U.S. and Coalition casualties that received at least 1 unit of packed red blood cells (PRBCs) or whole blood (WB). Given a lack of consensus on the definition of SMT recipients, we included those patients receiving the top quartile of PRBC and WB administered within the first 24 hours following arrival to a military treatment facility.

Results: We identified 25,897 adult casualties from January 1, 2007 to March 17, 2020. Within this dataset, 2,608 (9.0%) met inclusion for this analysis. The median number of total products administered within the first 24 hours was 8 units of PRBC or WB. The upper quartile was 18 units (n = 666). Compared to all other blood product recipients, patients in the SMT cohort had a higher median injury severity score (27 vs 18, $P < 0.001$), were most frequently injured by explosives (84.9% vs 68.6%, $P < 0.001$), had a higher mean emergency department (ED) pulse (128 vs 111, $P < 0.001$), a lower mean systolic blood pressure (122 vs 132 mm Hg, $P < 0.001$), and a higher mean international normalized ratio (1.68 vs 1.38, $P < 0.001$). SMT patients experienced lower survival to hospital discharge (85.8% vs 93.3%, $P < 0.001$).

Conclusions: Compared to all other PRBC and WB recipients, SMT patients experienced more injury by explosives, severe injury patterns, ED vital sign derangements, and mortality. These findings may help identify those casualties who may require earlier aggressive resuscitation. However, more data is needed to define this population early in their clinical course for early identification to facilitate rapid resource mobilization. Identifying casualties who are likely to die within 24 hours compared to those who are likely to survive, may assist in determining a threshold for a SMT.

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

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Abstract

Background: Penetrating thoracic injuries account for an essential subset of battlefield and civilian injuries that result in death. Current recommendations are to use commercially available nonocclusive chest seals. We review current evidence for which chest seal(s) is likely to be the most effective in treating open pneumothoraces.

Methods: A systematic review was conducted in accordance with the PRIMSA 2009 standard systematic review methodology, except where noted. The databases Pubmed, MEDLINE, CINAHL, Scopus, and gray sources were searched for all English-language, full-manuscript, experimental, quantitative studies of humans and animals concerning seal adherence or their efficacy at preventing tension pneumothoraces published between 1990 and 2020. A numerical analysis was used to provide the consensus recommendation.

Results: Of 683 eligible identified articles [PubMed 528 (77.3%), Scopus 87 (12.7%), CINAHL 67 (9.8%), one (0.1%) unpublished], six (0.9%) articles were included. Synthesis of all studies' results suggests a consensus recommendation for the Hyfin Vent Chest Seal and Russell Chest Seal. These two were the most effective chest seals, as previously investigated in a quantifiable, experimental study.

Conclusion: While chest seals are recommended in civilian and military prehospital medicine to improve patient survival, current evidence concerning the individual device's efficacy is limited. Further scientific, quantitative research is needed to clarify which commercially available chest seals are most effective and provide patients with penetrating chest trauma the best possible method for preventing or mitigating tension pneumothoraces.

Paediatric major incident triage: UK military tool offers best performance in predicting the need for time-critical major surgical and resuscitative intervention

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Abstract

Background: Children are frequently injured during major incidents (MI), including terrorist attacks, conflict and natural disasters. Triage facilitates healthcare resource allocation in order to maximise overall survival. A critical function of MI triage tools is to identify patients needing time-critical major resuscitative and surgical intervention (Priority 1 (P1) status). This study compares the performance of 11 MI triage tools in predicting P1 status in children from the UK Trauma Audit and Research Network (TARN) registry.

Methods: Patients aged <16 years within TARN (January 2008-December 2017) were included. 11 triage tools were applied to patients' first recorded pre-hospital physiology. Patients were retrospectively assigned triage categories (P1, P2, P3, Expectant or Dead) using predefined intervention-based criteria. Tools' performance in <16s were evaluated within four-yearly age subgroups, comparing tool-predicted and intervention-based priority status.

Findings: Amongst 4962 patients, mortality was 1.1% (n = 53); median Injury Severity Score (ISS) was 9 (IQR 9-16). Blunt injuries predominated (94.4%). 1343 (27.1%) met intervention-based criteria for P1, exhibiting greater intensive care requirement (60.2% vs. 8.5%, $p < 0.01$) and ISS (median 17 vs 9, $p < 0.01$) compared with P2 patients. The Battlefield Casualty Drills (BCD) Triage Sieve had greatest sensitivity (75.7%) in predicting P1 status in children <16 years, demonstrating a 38.4-49.8% improvement across all subgroups of children <12 years compared with the UK's current Paediatric Triage Tape (PTT). JumpSTART demonstrated low sensitivity in predicting P1 status in 4 to 8 year olds (35.5%) and 0 to 4 year olds (28.5%), and was outperformed by its adult counterpart START (60.6% and 59.6%).

Interpretation: The BCD Triage Sieve had greatest sensitivity in predicting P1 status in this paediatric trauma registry population: we recommend it replaces the PTT in UK practice. Users of JumpSTART may consider alternative tools. We recommend Lerner's triage category definitions when conducting MI evaluations.

Emergency Neurosurgery Performed by General Surgeons: A Systematic Review

Joseph N Hewitt [1], Christopher D Ovenden [2], John M Glynatsis [3], Ahad Sabab [3], Aashray K Gupta [1], Joshua G Kovoor [1][3], Adam J Wells [4], Guy J Maddern [5]

Abstract

Background: In under-resourced settings, general surgeons may be called upon to perform emergency operations within other specialties. Accordingly, we aimed to characterise patient outcomes after emergency neurosurgery performed by a general surgeon or general surgery trainee.

Methods: PubMed, Embase and the Cochrane Library were searched to 30 May 2021 for observational studies reporting outcomes after emergency neurosurgery performed by a general surgeon. Study screening, data extraction, and risk of bias using the Downs and Black checklist were performed in duplicate. Data on setting, operation undertaken, mortality rates and complications were extracted. Meta-analysis was planned but not possible due to heterogeneity. This study is registered with PROSPERO, CRD42021258097.

Results: From 632 records, 14 retrospective observational studies were included, covering a total sample of 1,988 operations. Four studies were from Australia, and the remaining 10 were, respectively, from 10 other countries. Most common operations performed were decompressive surgery with burr holes or craniectomy for head trauma and insertion of intracranial pressure monitors. Rural hospitals were the most common settings. Mortality rates for procedures performed by general surgeons at latest follow-up were heterogenous, ranging from 5% for evacuation of chronic subdural haematoma in Kenya to 81% in head injured patients in a Hong Kong study.

Conclusions: This is the first systematic review that synthesises the literature to characterise patient outcomes after neurosurgical operations performed by a general surgeon. Findings from this study may benefit global surgery performed in rural, remote, military or humanitarian settings.

Analysis of Nonbattle Deaths Among U.S. Service Members in the Deployed Environment

Tuan D Le [1][2], Jennifer M Gurney [1][3], Kevin S Akers [1], Kevin K Chung [4], Karan P Singh [2], Heuy-Ching Wang [5], Mark E Stackle [1], Anthony E Pusateri [5]

Abstract

Objective: Describe etiologies and trends in non-battle deaths (NBD) among deployed U.S. service members to identify areas for prevention.

Background: Injuries in combat are categorized as battle (result of hostile action) or nonbattle related. Previous work found that one-third of injured US military personnel in Iraq and Afghanistan had nonbattle injuries and emphasized prevention. NBD have not yet been characterized.

Methods: U.S. military casualty data for Iraq and Afghanistan from 2001 to 2014 were obtained from the Defense Casualty Analysis System (DCAS) and the Department of Defense Trauma Registry (DoDTR). Two databases were used because DoDTR does not capture prehospital deaths, while DCAS does not contain clinical details. Nonbattle injuries and NBD were identified, etiologies classified, and NBD trends were assessed using a weighted moving average and time-series analysis with autoregressive integrated moving average. Future NBD rates were forecast.

Results: DCAS recorded 59,799 casualties; 21.0% (n = 1431) of all deaths (n = 6745) were NBD. DoDTR recorded 29,958 casualties; 11.5% (n = 206) of all deaths (n = 1788) were NBD. After early fluctuations, NBD rates for both Iraq and Afghanistan stabilized at approximately 21%. Leading causes of NBD were gunshot wounds and vehicle accidents, accounting for 66%. Approximately 25% was self-inflicted. A 24% NBD rate was forecasted from 2015 through 2025.

Conclusions: Approximately 1 in 5 deaths were NBD. The majority were potentially preventable, including a significant proportion of self-inflicted injuries. A single comprehensive data repository would facilitate future mortality monitoring and performance improvement. These data may assist military leaders with implementing targeted safety strategies.

Staying on target: Maintaining a balanced resuscitation during damage-control resuscitation improves survival

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Abstract

Background: Damage-control resuscitation (DCR) improves survival in severely bleeding patients. However, deviating from balanced transfusion ratios during a resuscitation may limit this benefit. We hypothesized that maintaining a balanced resuscitation during DCR is independently associated with improved survival.

Methods: This was a secondary analysis of the Prospective Observational Multicenter Major Trauma Transfusion (PROMMTT) study. Patients receiving >3 U of packed red blood cells (PRBCs) during any 1-hour period over the first 6 hours and surviving beyond 30 minutes were included. Linear regression assessed the effect of percent time in a high-ratio range on 24-hour survival. We identified an optimal ratio and percent of time above the target ratio threshold by Youden's index. We compared patients with a 6-hour ratio above the target and above the percent time threshold (on-target) with all others (off-target). Kaplan-Meier analysis assessed the combined effect of blood product ratio and percent time over the target ratio on 24-hour and 30-day survival. Multivariable logistic regression identified factors independently associated with 24-hour and 30-day survival.

Results: Of 1,245 PROMMTT patients, 524 met the inclusion criteria. Optimal targets were plasma/PRBC and platelet/PRBC of 0.75 (3:4) and ≥40% time spent over this threshold. For plasma/PRBC, on-target (n = 213) versus off-target (n = 311) patients were younger (median, 31 years; interquartile range, [22-50] vs. 40 [25-54]; p = 0.002) with similar injury burdens and presenting physiology. Similar patterns were observed for platelet/PRBC on-target (n = 116) and off-target (n = 408) patients. After adjusting for differences, on-target plasma/PRBC patients had significantly improved 24-hour (odds ratio, 2.25; 95% confidence interval, 1.20-4.23) and 30-day (odds ratio, 1.97; 95% confidence interval, 1.14-3.41) survival, while on-target platelet/PRBC patients did not.

Conclusion: Maintaining a high ratio of plasma/PRBC during DCR is independently associated with improved survival. Performance improvement efforts and prospective studies should capture time spent in a high-ratio range.

Cold-stored whole blood and platelet counts in severe acute injury: A comparison of four retrospective cohorts

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Abstract

Background: Low-titer group O whole blood (LTOWB) is attractive for acute trauma care as it delivers concentrated and balanced hemostatic resuscitation in single large bags. Whether cold-stored LTOWB can sustain platelet counts is unclear.

Study design and methods: Four cohorts of trauma patients-three historic, one retrospective-were identified by their urgency of blood use. Admission and all subsequent platelet counts over the first 24 h of care were compared with t-tests. The cohorts were as follows: 1292 patients at Maryland Shock Trauma as described by Stansbury and colleagues in 2013; 35 patients enrolled locally in the 1:1:2 arm of the pragmatic randomized optimal plasma and platelet ratios (PROPPR) trial; 34 patients enrolled locally in the 1:1:1 arm of PROPPR; and 59 patients receiving more than 3 units of LTOWB enroute to or at our Level 1 trauma center, 2019-2020.

Results: Mean age of LTOWB units transfused was 9 ± 5 days and mean dose was 5 ± 2 units. All four cohorts were profoundly injured (mean Injury Severity Score ≥ 31), with mean first platelet counts 204-228 K/μ and subsequent counts approximately 100 k/μl lower. Through the first 24 h of care, mean platelet counts decreased least, 79 and 83 10^3 /μl, in the 1:1:1 PROPPR and LTOWB cohorts. Mean platelet counts in patients transfused with LTOWB remained stable after the third hour of care.

Discussion: LTOWB transfusion was associated with lesser mean decrease in platelet counts during the first 24 h after injury, similar to those observed among patients receiving components 1:1:1 component in the PROPPR study.

Keywords: damage control resuscitation; injury care; platelet concentrations after injury; platelet count; trauma; whole blood transfusion.

Analysis of Surgical Volume in Military Medical Treatment Facilities and Clinical Combat Readiness of US Military Surgeons

Michael K Dalton [1][2], Kyle N Remick [3], Michael Mathias [4], Quoc-Dien Trinh [1], Zara Cooper [1], Eric A Elster [3], Joel S Weissman [1]

Abstract

Importance: Low surgical volume in the US Military Health System (MHS) has been identified as a challenge to military surgeon readiness. The Uniformed Services University of Health Sciences, in partnership with the American College of Surgeons, developed the Knowledge, Skills, and Abilities (KSA) Clinical Readiness Program that includes a tool for quantifying the clinical readiness value of surgeon workload, known as the KSA metric.

Objective: To describe changes in US military general surgeon procedural volume and readiness using the KSA metric.

Design, setting, and participants: This cohort study analyzed general surgery workload performed across the MHS, including military and civilian facilities, between fiscal year 2015 and 2019 and the calculated KSA metric value. The surgeon-level readiness among military general surgeons was calculated based on the KSA metric readiness threshold. Data were obtained from TRICARE, the US Department of Defense health insurance product.

Main outcomes and measures: The main outcomes were general surgery procedural volumes and the KSA metric point value of those procedures across the MHS as well as the number of military general surgeons meeting the KSA metric readiness threshold. Aggregate facility and regional market-level claims data were used to calculate the procedural volumes and KSA metric readiness value of those procedures. Annual adjusted KSA metric points earned were used to determine the number of individual US military general surgeons meeting the readiness threshold.

Results: The number of general surgery procedures generating KSAs in military hospitals decreased 25.6%, from 128 377 in 2015 to 95 461 in 2019, with a 19.1% decrease in the number of general surgeon KSA points (from 7 155 563 to 5 790 001). From 2015 to 2019, there was a 3.2% increase in both the number of procedures (from 419 980 to 433 495) and KSA points (from 21 071 033 to 21 748 984) in civilian care settings. The proportion of military general surgeons meeting the KSA metric readiness threshold decreased from 16.7% (n = 97) in 2015 to 10.1% (n = 68) in 2019.

Conclusions and relevance: This study noted that the number of KSA metric points and procedural volume in military hospitals has been decreasing since 2015, whereas both measures have increased in civilian facilities. The findings suggest that loss of surgical workload has resulted in further decreases in military surgeon readiness and may require substantial changes in patient care flow in the MHS to reverse the change.