
MAYO CLINIC
MAYO ONE

Hemorrhagic Shock

What is the Best Treatment?

Dan Hankins, MD, FACEP

Consultant, Dept. of Emergency Medicine

Mayo Clinic

Co-Medical Director, Mayo Clinic Medical Transport

President, Association of Air Medical Services

MAYO CLINIC
Medical Transport

Thank you to the ASA and the FNA for inviting me to do this presentation at this ASA+FNA 2011 conference

MAYO CLINIC
Medical Transport

MAYO CLINIC
Medical Transport

THE PREVENTIVE TREATMENT OF WOUND SHOCK

W. B. CANNON, M.D. (BOSTON)
Captain, M. R. C., U. S. Army

JOHN FRASER
Captain, M. C., R. A. M. C.

E. M. COWELL
Captain, R. A. M. C., S. R.

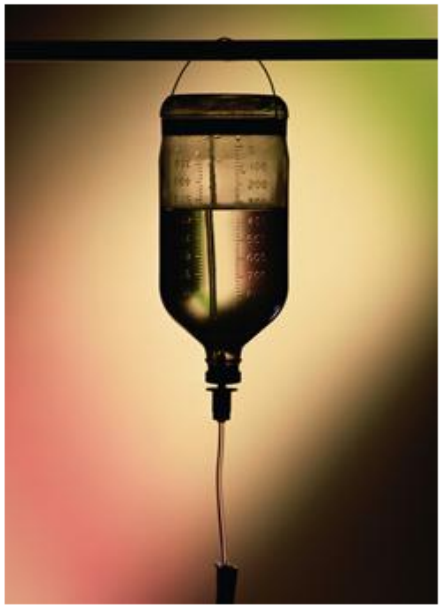
FRANCE

INTRODUCTION

Whatever the nature of the [illegible]

Giving IV fluids on scene might raise death risk for trauma victims

Updated 1/10/2011 4:52 PM | Comments 15 | Recommend 13
E-mail | Save | Print | RSS



Enlarge By PhotoDisc

Patients whose injuries were due to a stabbing or shooting were found to face a 25% elevated risk of death if they were given a pre-hospital IV, relative to those who weren't.

By Alan Mozes, HealthDay

The long-standing practice of first giving severely wounded trauma patients intravenous (IV) fluids before bringing them to a trauma center may actually raise their risk of death, a new study suggests.

The finding flies in the face of common medical wisdom and mandated protocols in some states that require that IV fluids be given to trauma patients immediately if their blood pressure drops precipitously.

But a fresh analysis of data on nearly 777,000 trauma patients revealed that, overall, those who are given pre-hospital IV fluids are actually 11% more likely to die than those who aren't, not only because of transport delays but also in part because of the increased risk for bleeding that can accompany a fluid-induced increase in blood pressure.

"IV fluid administration to trauma patients pre-hospital is like one of those things that's been thought of as mainstay, and that got implemented before there was science that showed it was actually the best thing to do," said study author Dr. Elliott R. Haut, an associate professor in both the department of surgery and the department of anesthesiology & critical care at the Johns Hopkins University School of Medicine in Baltimore. "And now of course it's a standard of care. And it's very hard to buck the trend with respect to something that's been done for 25 years."

But, he added, "the general idea here is that although obviously

Share
Yahoo! Buzz
Add to Mixx
Facebook
Twitter
More
Subscribe
myYahoo
iGoogle
More

Featured video

Protesters
Party in D.C. after Mubarak resignation.

At the movies
Aniston, Sandler talk 'Just Go With It'

Comics
Spidey fights Ryu in 'Marvel vs. Capcom 3'

More: Video

Pre-hospital Hemorrhage Management

- Mechanical measures
  - Direct hand pressure
  - Pressure dressing
  - Tourniquet or 2
- Hemostatic agents
- PRBCs
- TXA
- Factor rVIIa (experimental)?, PCC?
- Liquid plasma for rural, not urban, resuscitation
- Hypotensive (restricted) resuscitation

MAYO CLINIC Medical Transport

Predictors

- Lactate
- Base deficit
- HR
- BP

MAYO CLINIC
Medical Transport

Lactate Is a Better Predictor than Systolic Blood Pressure for Determining Blood Requirement and Mortality: Could Prehospital Measures Improve Trauma Triage?

Marianne J Vandromme, MD, MSPH, Russell L Griffin, MPH, Jordan A Weinberg, MD, FACS, Loring W Rue III, MD, FACS, Jeffrey D Kerby, MD, PhD, FACS

BACKGROUND: Standard hemodynamic evaluation of patients in shock may underestimate severity of hemorrhage given physiologic compensation. Blood lactate (BL) is an important adjunct in characterizing shock, and point-of-care devices are currently available for use in the prehospital (PH) setting. The objective of this study was to determine if BL levels have better predictive value when compared with systolic blood pressure (SBP) for identifying patients with an elevated risk of significant transfusion and mortality in a hemodynamically indeterminant cohort.

STUDY DESIGN: We selected trauma patients admitted to a level I trauma center over a 9-year period with SBP between 90 and 110 mmHg. The predictive capability of initial emergency department (ED) BL for needing ≥6 units packed RBCs within 24 hours postinjury and mortality was compared with PH-SBP and ED-SBP by comparing estimated area under the receiver operator curve (AUC).

RESULTS: We identified 2,413 patients with ED-SBP and 787 patients with PH-SBP and ED-BL. ED-BL was statistically better than PH-SBP ($p = 0.0025$) and ED-SBP ($p < 0.0001$) in predicting patients who will need ≥ 6 U packed RBCs within 24 hours postinjury (AUC: ED-BL, 0.72 vs PH-SBP, 0.61; ED-BL, 0.76 vs ED-SBP, 0.60). ED-BL was also a better predictor than both PH-SBP ($p = 0.0235$) and ED-SBP ($p < 0.0001$) for mortality (AUC: ED-BL, 0.74 vs PH-SBP, 0.60; ED-BL, 0.76 vs ED-SBP, 0.61).

CONCLUSIONS: ED-BL is a better predictor than SBP in identifying patients requiring significant transfusion and mortality in this cohort with indeterminant SBP. These findings suggest that point-of-care BL measurements could improve trauma triage and better identify patients for enrollment in interventional trials. Further studies using BL measurement in the PH environment are warranted. (J Am Coll Surg 2010;210:861–869. © 2010 by the American College of Surgeons)

The Journal of TRAUMA® *Injury, Infection, and Critical Care*

Base Deficit-Based Predictive Modeling of Outcome in Trauma Patients Admitted to Intensive Care Units in Dutch Trauma Centers

Frank Kroezen, MD, Taco S. Bijlsma, MD, PhD, Mike S. L. Liem, MD, PhD, J. Dik Meeuwis, MD, PhD, FACS, and Luke P. H. Leenen, MD, PhD, FACS

Background: Worldwide, the base deficit is available as an objective indicator of acid base status. We used the base deficit as a measure of physiologic derangement in a Trauma and Injury Severity Score (TRISS)-like model as a predictor for outcome in trauma patients.

Methods: We prospectively recorded data of 349 consecutive trauma patients admitted to the intensive care unit and calculated Revised Trauma Score, Injury Severity Score and Abbreviated Injury Scale, and TRISS and correlated them with the simultaneously determined base deficit value. The delta base deficit is introduced, which is the absolute difference of the base deficit from its normal range (−2 to 2). A statistical model analogous to the TRISS model was designed in which the physiologic disturbance reflected by the Revised Trauma Score was replaced by the delta base deficit [Base Excess Injury Severity Scale (BISS) model]. Calculating the area under the curve (AUC) of the respective receiver operating characteristic curve compared these two models. Finally, the BISS model was validated in a patient group from another tertiary referral hospital in which similar data were recorded prospectively.

Results: We demonstrated a significant correlation between the delta base deficit and the calculated trauma scoring systems. Moreover, the delta base deficit is significantly correlated with mortality. The BISS performed better than the TRISS did when evaluated by the AUC of the receiver operating characteristic curves (AUC 0.806 vs. 0.803, respectively). Validation in an independent prospectively compiled dataset from another referral center showed comparable and even better results (AUC 0.891 vs. 0.885, respectively).

Conclusions: The performance of our proposed BISS model was superior to that of the TRISS model in the populations under investigation. Nevertheless, given the ease of assessment and the objective value of the base deficit, it may be considered as a good method to predict outcome and evaluate care of trauma patients. Whether this can be translated to trauma patients in general needs further investigation.

J Trauma. 2007;63:908–913.

Heart Rate Variability as a Triage Tool in Patients With Trauma During Prehospital Helicopter Transport

David R. King, MD, Michael P. Ogilvie, MD, MBA, Bruno M. T. Pereira, MD, FCCM, Yuchiao Chang, PhD, Ronald J. Manning, RN, MSPH, Jeffrey A. Conner, RN, BSN, Carl I. Schulman, MD, MSPH, FACS, Mark G. McKenney, MD, MBA, FACS, and Kenneth G. Proctor, PhD

Background: Prehospital triage of patients with trauma is routinely challenging, but more so in mass casualty situations and military operations. The purpose of this study was to prospectively test whether heart rate variability (HRV) could be used as a triage tool during helicopter transport of civilian patients with trauma.

Methods: After institutional review board approval and waiver of informed consent, 75 patients with trauma requiring prehospital helicopter transport to our level I center (from December 2007 to November 2008) were prospectively instrumented with a 2-Channel SEER Light recorder (GE Healthcare, Milwaukee, WI). HRV was analyzed with a Mars Holter monitor system and proprietary software. SDNN (standard deviation [SD] of the normal-to-normal R-R interval), as an index of HRV, was correlated with prehospital trauma triage criteria, base deficit, seriousness of injury, operative interventions, outcome, and other data extracted from the patients' medical records. There were no interventions or medical decisions based on HRV. Data were excluded only if there was measurement artifact or technical problems with the recordings.

Results: The demographics were mean age 47 years, 63% men, 88% blunt, 25% traumatic brain injury, 9% mortality. Prehospital SDNN predicted patients with base excess ≤ -6, those defined as seriously injured and benefiting from trauma center care, as well as patients requiring a life-saving procedure in the operating room. No other available data, including prehospital en-route vital signs, predicted any of these. The sensitivity, specificity, positive predictive value, and negative predictive value were 80%, 75%, 33%, 96%, respectively, with and an overall accuracy of 76% for predicting uation for minimally injured patients. A prospective, randomized trial in a larger patient population is indicated.

Key Words: Combat casualty care, Base deficit, Vital sign monitor.

(*J Trauma.* 2009;67: 436–440)

INTRODUCTION

Appropriate triage of traumatized patients remains a challenge. Not all injured patients will require, or even benefit from, care at a level I center and activation of a dedicated trauma team. Rapidly deciding which patients will truly benefit from this more costly trauma care delivery system is difficult in many field situations. Additionally, unnecessary helicopter transport of minimally injured patients is particularly wasteful, cost consuming, and offers no additional care to the patient. The overall global goal of trauma triage and helicopter transport is to match the most aggressive and available medical resources with the needs of the most seriously injured patients (appropriate triage) while minimizing unintentional exclusion of a patient who would benefit from a level I center, trauma team activation, and helicopter transport (undertriage).

ORIGINAL ARTICLE (*J Trauma. 2010;68: 1289–1295*)

Just One Drop: The Significance of a Single Hypotensive Blood Pressure Reading During Trauma Resuscitations

Mark J. Seamon, MD, Cristina Feather, MD, Brian P. Smith, MD, Heather Kulp, MPH, John P. Gaughan, PhD, and Amy J. Goldberg, MD

Background: Single, isolated hypotensive blood pressure (BP) measurements frequently are ignored or considered "erroneous." Although their clinical significance remains unknown, we hypothesized that single, isolated hypotensive BP readings during trauma resuscitations signify the presence of severe injuries that often warrant immediate intervention.

Methods: A prospective observational study was performed on all trauma patients admitted from June 2008 to January 2009. Patients with a single systolic blood pressure (SBP) reading <110 mm Hg during their trauma resuscitation were evaluated, and demographics, hemodynamics, resuscitation (fluids, blood products, and duration), injuries, and operative or endovascular management were analyzed. Single and multiple variable logistic regression analyses were performed. Cutpoint analysis of the entire range of lowest single SBP measurements determined which SBP value best predicted the need for immediate therapeutic intervention.

Results: Patients (n = 145) were predominantly male (77.2%) but age (mean, 35.1 ± 15.3 years) and injury mechanisms varied (penetrating, 46.2%; blunt, 53.8%). Cutpoint analysis determined that a single SBP reading <105 mm Hg best predicted the need for immediate therapeutic intervention. Although 38.1% patients with isolated SBP <105 mm Hg measurements underwent immediate therapeutic operative or endovascular procedures, only 10.4% ($p < 0.001$) with isolated SBP >105 mm Hg

Advanced Trauma Life Support teaches that hemorrhagic shock is not clinically evident until tachycardia and narrowed pulse pressure develops during a 15% to 30% blood volume, class II hemorrhage.[1] Hypotension becomes clinically apparent during class III hemorrhage when >1,500 mL of blood, or 30% of circulating blood volume, is lost.[1] Despite this well-established classification scheme, tachycardia in trauma patients may be an unreliable indicator of injury,[2–9] and persistent hypotension is often a late manifestation of shock that becomes evident once end-organ damage has already begun in the decompensated shock state.[10–13]

However, brief episodes of hypotension may be an early indication of impending shock. Transient hypotension during prehospital care or in the surgical intensive care unit (ICU) has been reported and determined to be predictive of both severe injury and poor outcome.[14–21] Despite these reports, single, isolated hypotensive blood pressure (BP) measurements during trauma resuscitations are often ignored or considered "erroneous."

Although their significance remains unknown, we hy-

Conclusions: Single, isolated hypotensive BP measurements during trauma resuscitations should not be ignored or dismissed. Instead, our results suggest that a single SBP reading <105 mm Hg is associated with severe injuries that often require immediate operative or endovascular treatment and surgical intensive care unit admission.

Hemorrhage Resuscitation

With What Should You Intervene?

- Crystalloid?
- Colloid?
- Other fluids?
- Blood products?
- Other therapeutic interventions?

Hemorrhage Resuscitation
With What Should You Intervene?
Considerations

- 32 randomized, controlled studies showing no mortality benefit of albumin over crystalloids
- 55 randomized, controlled studies showing no reduced mortality of colloids over crystalloids (Consider Hopkins Study, though)
- Review of multiple trials show no increased safety or efficacy of one colloid over another

ORIGINAL STUDY (*Ann Surg 2011;253:371–378*)

Prehospital Intravenous Fluid Administration Is Associated With Higher Mortality in Trauma Patients: A National Trauma Data Bank Analysis

Elliott R. Haut, MD, Brian T. Kalish, BA*, Bryan A. Cotton, MD, MPH†, David T. Efron, MD*, Adil H. Haider, MD, MPH*‡, Kent A. Stevens, MD, MPH*‡, Alicia N. Kieninger, MD§, Edward E. Cornwell, III, MD¶, and David C. Chang, MBA, MPH, PhD‖*

Objective: Prehospital intravenous (IV) fluid administration is common in trauma patients, although little evidence supports this practice. We hypothesized that trauma patients who received prehospital IV fluids have higher mortality than trauma patients who did not receive IV fluids in the prehospital setting.

Methods: We performed a retrospective cohort study of patients from the National Trauma Data Bank. Multiple logistic regression was used with mortality as the primary outcome measure. We compared patients with versus without prehospital IV fluid administration, using patient demographics, mechanism, physiologic and anatomic injury severity, and other prehospital procedures as covariates. Subset analysis was performed based on mechanism (blunt/penetrating), hypotension, immediate surgery, severe head injury, and injury severity score.

Results: A total of 776,734 patients were studied. Approximately half (49.3%) received prehospital IV. Overall mortality was 4.6%. Unadjusted mortality was significantly higher in patients receiving prehospital IV fluids (4.8% vs. 4.5%, $P < 0.001$). Multivariable analysis demonstrated that patients receiving

vital organ perfusion.[1] Since its inception, the American College of Surgeons Advanced Trauma Life Support course has emphasized immediate treatment of trauma patients with IV fluids, although in the newest eighth edition, the course now emphasizes a more "balanced" approach.[2] The routine practice of IV fluid administration in the prehospital arena is touted with great enthusiasm but little data exist to support its use.[3,4]

An increasing body of evidence has demonstrated that IV fluid administration does not improve survival in trauma and may actually be of harm in certain subsets of trauma patients.[5–9] One theory for the possibility of harm is based upon the delay of transport to definitive care. Scene placement of venous access is not only associated with increased scene time but also increased overall time to hospital, in some cases the time to place an IV exceeds that of the actual transport itself.[10] In hypotensive patients and those with primary torso injuries, scene placement times exceed that of en route IV line placement.[11,12] Many trauma providers believe that the "scoop and run" approach,

Prehospital Fluids
Hopkins Study

- 776,734 patients from NTDB
- Retrospective
- 49.3% of patients got fluids
- Overall mortality was 4.6%
- Unadjusted mortality was significantly higher in patients receiving prehospital IV fluids (4.8% vs.4.5%, *P < 0.001)*

MAYO CLINIC
Medical Transport

Prehospital Fluids
Hopkins Study

- Multivariable analysis demonstrated that patients receiving IV fluids were significantly more likely to die
  - (odds ratio [OR] 1.11, 95% confidence interval [CI] 1.05–1.17)
- The association was identified in nearly all subsets of trauma patients

Prehospital Fluids
Hopkins Study

- It is especially marked in patients with penetrating mechanism (OR 1.25, 95% CI 1.08–1.45), hypotension (OR 1.44, 95% CI 1.29–1.59), severe head injury (OR 1.34, 95% CI 1.17–1.54), and patients undergoing immediate surgery (OR 1.35, 95% CI 1.22–1.50)

Prehospital Fluids

Hopkins Study

- **Conclusions: The harm associated with prehospital IV fluid administration is significant for victims of trauma. *The routine use of pre-hospital IV fluid administration for all trauma patients should be discouraged***

MAYO CLINIC
Medical Transport

Other Crystalloids?
HSS?

FEATURE ARTICLE

Out-of-hospital Hypertonic Resuscitation After Traumatic Hypovolemic Shock

A Randomized, Placebo Controlled Trial

Eileen M. Bulger, MD, Susanne May, PhD*, Jeffery D. Kerby, MD, PhD†, Scott Emerson, MD, PhD*, Ian G. Stiell, MD‡, Martin A. Schreiber, MD§, Karen J. Brasel, MD, MPH‖, Samuel A. Tisherman, MD¶, Raul Coimbra, MD, PhD#, Sandro Rizoli, MD, PhD**, Joseph P. Minei, MD††, J. Steven Hata, MD‡‡, George Sopko, MD, MPH§§, David C. Evans, MD‖‖, and David B. Hoyt, MD¶¶ for the ROC investigators*

Objective: To determine whether out-of-hospital administration of hypertonic fluids would improve survival after severe injury with hemorrhagic shock.
Background: Hypertonic fluids have potential benefit in the resuscitation of severely injured patients because of rapid restoration of tissue perfusion, with a smaller volume, and modulation of the inflammatory response, to reduce subsequent organ injury.
Methods: Multicenter, randomized, blinded clinical trial, May 2006 to August 2008, 114 emergency medical services agencies in North America within the

Conclusion: Among injured patients with hypovolemic shock, initial resuscitation fluid treatment with either HS or HSD compared with NS, did not result in superior 28-day survival. However, interpretation of these findings is limited by the early stopping of the trial. **Clinical Trial Registration: ClinicalTrials.gov, NCT00316017]**

(*Ann Surg* 2011;253:431–441)

MAYO CLINIC
Medical Transport

Hextend®, a Physiologically Balanced Plasma Expander for Large Volume Use in Major Surgery: A Randomized Phase III Clinical Trial

T. J. Gan, MB, FRCA*, E. Bennett-Guerrero, MD†, B. Phillips-Bute, PhD*, H. Wakeling, MB, FRCA*, D. M. Moskowitz, MD†, Y. Olufolabi, MB*, S. N. Konstadt, MD†, C. Bradford, RN†, P. S. A. Glass, MD*, S. J. Machin, FRCP‡, M. G. Mythen, MD§, and the Hextend® Study Group[1]

*Department of Anesthesiology, Duke University Medical Center, Durham, North Carolina; †Department of Anesthesiology, The Mount Sinai Medical Center, New York, New York; and Departments of ‡Haematology and §Anaesthesia, University College London Hospitals, London, England

Hextend® (BioTime, Inc., Berkeley, CA) is a new plasma volume expander containing 6% hetastarch, balanced electrolytes, a lactate buffer, and physiological levels of glucose. In preclinical studies, its use in shock models was associated with an improvement in outcome compared with alternatives, such as albumin or 6% hetastarch in saline. In a prospective, randomized, two-center study (n = 120), we compared the efficacy and safety of Hextend® versus 6% hetastarch in saline (HES) for the treatment of hypovolemia during major surgery. Patients at one center had a blood sample drawn at the beginning and the end of surgery for thromboelastographic (TEG) analysis. Hextend® was as effective as HES for the treatment of hypovolemia. Patients received an average of 1596 mL of Hextend®: 42% received >20 mL/kg up to a total of 5000 mL. No patient received albumin. Hextend®-treated patients required less intraoperative calcium (4 vs 220 mg; $P < 0.05$). In a subset analysis of patients receiving red blood cell transfusions (n = 56; 47%), Hextend®-treated patients had a lower mean estimated blood loss (956 mL less; $P = 0.02$) and were less likely to receive calcium supplementation (P = 0.04). Patients receiving HES demonstrated significant prolongation of time to onset of clot formation (based on TEG) not seen in the Hextend® patients ($P < 0.05$). No Hextend® patient experienced a related serious adverse event, and there was no difference in the total number of adverse events between the two groups. The results of this study demonstrate that Hextend®, with its novel buffered, balanced electrolyte formulation, is as effective as 6% hetastarch in saline for the treatment of hypovolemia and may be a safe alternative even when used in volumes up to 5 L. Implications: Hextend® (BioTime, Inc., Berkeley, CA) is a new plasma volume expander containing 6% hetastarch, balanced electrolytes, a lactate buffer, and a physiological level of glucose. It is as effective as 6% hetastarch in saline for the treatment of hypovolemia but has a more favorable side effects profile in volumes of up to 5 L compared with 6% hetastarch in saline.

(Anesth Analg 1999;88:992–8)

ANESTHESIA & ANALGESIA

Hetastarch

- Used in SW Asia because more portable
- Probably no better survival, but does not cause coagulopathy
- No more than 1500cc

Various blood products

- PRBCs
  - Oxygen carrying capacity
  - No clotting factor
- FFP/Thawed plasma
  - No oxygen carrying capacity
  - Does have clotting factors
- Cryoprecipitate
  - Provides factor VIII
- Albumin
  - Volume expander
- Whole Blood
  - Provides oxygen carrying capacity
  - Provides clotting factors
  - Provides platelets
  - Provides volume

The Journal of TRAUMA® *Injury, Infection, and Critical Care*

The Ratio of Blood Products Transfused Affects Mortality in Patients Receiving Massive Transfusions at a Combat Support Hospital

Matthew A. Borgman, MD, Philip C. Spinella, MD, Jeremy G. Perkins, MD, Kurt W. Grathwohl, MD, Thomas Repine, MD, Alec C. Beekley, MD, James Sebesta, MD, Donald Jenkins, MD, Charles E. Wade, PhD, and John B. Holcomb, MD

Background: Patients with severe traumatic injuries often present with coagulopathy and require massive transfusion. The risk of death from hemorrhagic shock increases in this population. To treat the coagulopathy of trauma, some have suggested early, aggressive correction using a 1:1 ratio of plasma to red blood cell (RBC) units.

Methods: We performed a retrospective chart review of 246 patients at a US Army combat support hospital, each of who received a massive transfusion (≥10 units of RBCs in 24 hours). Three groups of patients were constructed according to the plasma to RBC ratio transfused during massive transfusion. Mortality rates and the cause of death were compared among groups.

Results: For the low ratio group the plasma to RBC median ratio was 1:8 (interquartile range, 0:12–1:5), for the medium ratio group, 1:2.5 (interquartile range, 1:3.0–1:2.3), and for the high ratio group, 1:1.4 (interquartile range, 1:1.7–1:1.2) ($p < 0.001$). Median Injury Severity Score (ISS) was 18 for all groups (interquartile range, 14–25). For low, medium, and high plasma to RBC ratios, overall mortality rates were 65%, 35%, and 19%, ($p < 0.001$); and hemorrhage mortality rates were 92.5%, 78%, and 37%, respectively, ($p < 0.001$). Upon logistic regression, plasma to RBC ratio was independently associated with survival (odds ratio 8.6, 95% confidence interval 2.1–35.2).

Conclusions: In patients with combat related trauma requiring massive transfusion, a high 1:1.4 plasma to RBC ratio is independently associated with improved survival to hospital discharge, primarily by decreasing death from hemorrhage. For practical purposes, massive transfusion protocols should utilize a 1:1 ratio of plasma to RBCs for all patients who are hypocoagulable with traumatic injuries.

Key Words: Blood components, Fresh frozen plasma, Trauma, Coagulopathy.

J Trauma. 2007;63:805–813.

MAYO CLINIC
Medical Transport

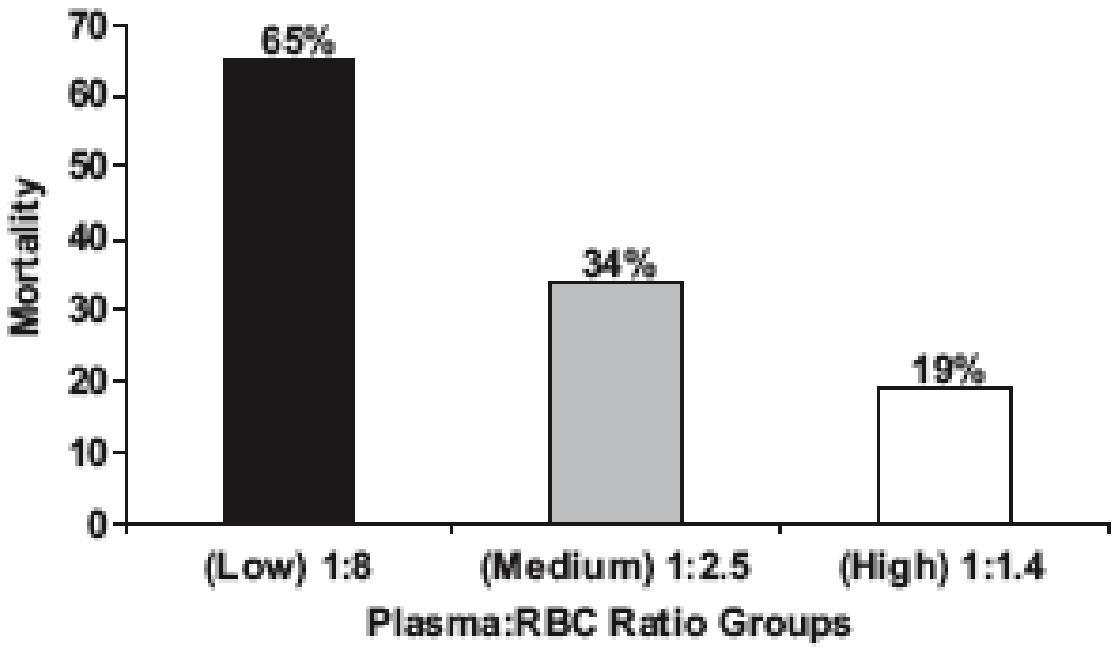


Fig. 1. *Percentage mortality associated with low, medium, and high plasma to RBC ratios transfused at admission. Ratios are median ratios per group and include units of fresh whole blood counted both as plasma and RBCs.*

MAYO CLINIC
Medical Transport

Increased Plasma and Platelet to Red Blood Cell Ratios Improves Outcome in 466 Massively Transfused Civilian Trauma Patients

John B. Holcomb, MD, Charles E. Wade, PhD,* Joel E. Michalek, PhD,† Gary B. Chisholm, PhD,† Lee Ann Zarzabal, MS,† Martin A. Schreiber, MD,‡ Ernest A. Gonzalez, MD,§ Gregory J. Pomper, MD,¶ Jeremy G. Perkins, MD,‖ Phillip C. Spinella, MD,** Kari L. Williams, RN,* and Myung S. Park, MD**

Objective: To determine the effect of blood component ratios in massive transfusion (MT), we hypothesized that increased use of plasma and platelet to red blood cell (RBC) ratios would result in decreased early hemorrhagic death and this benefit would be sustained over the ensuing hospitalization.

Summary Background Data: Civilian guidelines for massive transfusion (MT ≥10 units of RBC in 24 hours) have typically recommend a 1:3 ratio of plasma:RBC, whereas optimal platelet:RBC ratios are unknown. Conversely, military data shows that a plasma:RBC ratio approaching 1:1 improves long term outcomes in MT combat casualties. There is little consensus on optimal platelet transfusions in either civilian or military practice. At present, the optimal combinations of plasma, platelet, and RBCs for MT in civilian patients is unclear.

Methods: Records of 467 MT trauma patients transported from the scene to 16 level 1 trauma centers between July 2005 and June 2006 were reviewed. One patient who died within 30 minutes of admission was excluded. Based on high and low plasma and platelet to RBC ratios, 4 groups were analyzed.

Results: Among 466 MT patients, survival varied by center from 41% to 74%. Mean injury severity score varied by center from 22 to

Thirty-day survival was increased in patients with high plasma:RBC ratio (≥1:2) relative to those with low plasma:RBC ratio (<1:2) (low: 40.4% vs. high: 59.6%, $P < 0.01$). Similarly, 30-day survival was increased in patients with high platelet:RBC ratio (≥1:2) relative to those with low platelet:RBC ratio (<1:2) (low: 40.1% vs. high: 59.9%, $P < 0.01$). The combination of high plasma and high platelet to RBC ratios were associated with decreased truncal hemorrhage, increased 6-hour, 24-hour, and 30-day survival, and increased intensive care unit, ventilator, and hospital-free days ($P < 0.05$), with no change in multiple organ failure deaths. Statistical modeling indicated that a clinical guideline with mean plasma:RBC ratio equal to 1:1 would encompass 98% of patients within the optimal 1:2 ratio.

Conclusions: Current transfusion practices and survival rates of MT patients vary widely among trauma centers. Conventional MT guidelines may underestimate the optimal plasma and platelet to RBC ratios. Survival in civilian MT patients is associated with increased plasma and platelet ratios. Massive transfusion practice guidelines should aim for a 1:1:1 ratio of plasma:platelets:RBCs.

(*Ann Surg* 2008;248: 447–458)

The Journal of TRAUMA® Injury, Infection, and Critical Care

An FFP:PRBC Transfusion Ratio ≥1:1.5 Is Associated With A Lower Risk Of Mortality After Massive Transfusion

Jason L. Sperry, MD, MPH, Juan B. Ochoa, MD, Scott R. Gunn, MD, Louis H. Alarcon, MD, Joseph P. Minei, MD, Joseph Cuschieri, MD, Matthew R. Rosengart, MD, MPH, Ronald V. Maier, MD, Timothy R. Billiar, MD, Andrew B. Peitzman, MD, Ernest E. Moore, MD, and The Inflammation the Host Response to Injury Investigators

Objective: The detrimental effects of coagulopathy, hypothermia, and acidosis are well described as markers for mortality after traumatic hemorrhage. Recent military experience suggests that a high fresh frozen plasma (FFP):packed red blood cell (PRBC) transfusion ratio improves outcome; however, the appropriate ratio these transfusion products should be given remains to be established in a civilian trauma population.

Methods: Data were obtained from a multicenter prospective cohort study evaluating clinical outcomes in blunt injured adults with hemorrhagic shock. Those patients who required ≥8 units PRBCs within the first 12 hours postinjury were analyzed (n = 415).

Results: Patients who received transfusion products in ≥1:1.50 FFP:PRBC ratio (high F:P ratio, n = 102) versus <1:1.50 FFP:PRBC ratio (low F:P, n = 313) required significantly less blood transfusion at 24 hours (16 ± 9 units vs. 22 ± 17 units, $p = 0.001$). Crude mortality differences between the groups did not reach statistical significance (high F:P 28% vs. low F:P 35%, $p = 0.202$); however, there was a significant difference in early (24 hour) mortality (high F:P 3.9% vs. low F:P 12.8%, $p = 0.012$). Cox proportional hazard regression revealed that receiving a high F:P ratio was independently associated with 52% lower risk of mortality after adjusting for important confounders (HR 0.48, $p = 0.002$, 95% CI 0.3–0.8). A high F:P ratio was not associated with a higher risk of organ failure or nosocomial infection, however, was associated with almost a twofold higher risk of acute respiratory distress syndrome, after controlling for important confounders.

Conclusions: In patients requiring ≥8 units of blood after serious blunt injury, an FFP:PRBC transfusion ratio ≥1:1.5 was associated with a significant lower risk of mortality but a higher risk of acute respiratory distress syndrome. The mortality risk reduction was most relevant to mortality within the first 48 hours from the time of injury. These results suggest that the mortality risk associated with an FFP:PRBC ratio <1:1.5 may occur early, possibly secondary to ongoing coagulopathy and hemorrhage. This analysis provides further justification for the prospective trial investigation into the optimal FFP:PRBC ratio required in massive transfusion practice.

Key Words: Massive transfusion, Transfusion ratio, Plasma, Cox proportional hazard regression.

J Trauma. 2008;65:986–993.

Blood Usage in Rotor-Wing Transport

Kathleen S. Berns, RN,[1] Scott P. Zietlow, MD[1,2]

1. Mayo One, St. Mary's Hospital, Rochester, Minn.
2. Mayo Clinic, Rochester, Minn.

Address for correspondence and reprints: Kathleen S. Berns, RN, Mayo One, St. Mary's Hospital, 1216 2nd St. SW, Rochester, MN 55902

Key Words: blood usage, hemorrhagic shock, O-negative red blood cells, rotor-wing transport

Presented at the ADAC World Congress AIRMED '96 in Munich, Germany, on June 12, 1996.

Presented at the 1997 Air Medical Transport

Abstract

Introduction: Blood transfusion for hemorrhagic shock is standard therapy. The purpose of this study was to document the development of protocols for administering red blood cells and review the experience with in-flight blood transfusions.

Setting: This study was conducted at a hospital-based rotor-wing (RW) program whose service area is a large rural area in southeastern Minnesota. A BK 117 with a flight nurse/flight nurse configuration was used.

Methods: The RW registry was accessed during a 3-year period (August 1993 to July 1996), and 2131 records were reviewed to retrospectively analyze blood use during trans-

Introduction

In recent years, blood transfusion for hemorrhagic shock has become standard therapy. The first record of successful treatment of hemorrhagic shock is from the early 1800s when a woman with life-threatening postpartum hemorrhage was transfused.[1] Since that time, the science of blood transfusions has evolved considerably, and the first blood bank was established in 1937.[2] Today millions of units of blood are administered each year in the United States.

Resuscitation with blood products has been a staple of trauma care for many years. Standard protocols, such as

Mayo One
Staffing and equipment...

We are the only Critical Care Transport Service in the world carrying plasma, let alone, thawed plasma

MAYO CLINIC
Medical Transport

Blood Product Usage Protocol

- Before:
  - pRBC's and plasma (if available) should be given to patients who are hemorrhaging
  - pRBC's and plasma (if available) should be alternated as follows: 2 units pRBC's then 2 units of plasma, then 2 units of pRBC's
- Now:
  - In patients needing massive blood transfusion, use of plasma prior to PRBC administration

MAYO CLINIC
Medical Transport

Use of Thawed Plasma

- The use of plasma in the helicopter system creates a field ready, mobile blood bank, allowing the resources of a Level 1 Trauma Center to be accessible on scene
- Pre-hospital plasma transfusion enables
  - Initiation of Warfarin reversal in TBI, and
  - TIC correction by early achievement of a 1:1 plasma:RBC ratio and eliminates the plasma deficit in hemorrhaging trauma patients

MAYO CLINIC
Medical Transport

Field PRBCs and Plasma

- Considerations
  - Requires blood banking/lab support
  - Logistical re-supply
  - Refrigeration

MAYO CLINIC
Medical Transport

THAWED PLASMA USAGE IN CRITICAL CARE TRANSPORT

K. Berns, S. Zielow, D. Hankins

Introduction: The use of Fresh Frozen Plasma (FFP) has been a well established treatment modality and in recent years, thawed plasma use has been under development in select major medical centers. A literature search revealed no research on thawed plasma use in civilian, pre-hospital critical care transport. The aim of this study is to determine if early administration of thawed plasma in the critical care transport environment will safely decrease the International Normalized Ratio (INR) and/or bleeding.

Methods: Thawed plasma was supplied to one of this services helicopters beginning in February 2008 following development of a guideline for its use. The other two helicopters did not carry it due to availability and logistics. A retrospective chart review of critical care transport records from February 2008 to April 2010 was completed. Eighteen transports were found where plasma was administered. Statistical analysis was not done because of low volume. This study will be ongoing and analyzed when sufficient numbers are reached.

Results: Sixty-seven percent of the patients were male with a mean age of 62 years. Plasma was used on eighteen transports for a total of 30 units infused. Vitamin K had been administered to 7 patients (39%). The majority of transports were from a referring facility versus a scene (16 vs. 2). The average transport time was 27 minutes. The majority of plasma usage was for patients with a medical hemorrhagic stroke or trauma. The reasons for use of plasma were either an elevated INR in patients taking Coumadin or per the massive transfusion protocol. Thirty-three percent of the patients also received transfusion of red blood cells. The average INR prior to transport was 5.13 and was 2.6 on the first INR at the receiving facility. The average hospital stay for patients who received plasma was 9 days. Forty-seven percent lived to hospital discharge and 53% died. There were no transfusion reactions during the time of the study.

Conclusion: Although the number of patients in this study is small, it does suggest that the use of thawed plasma given in the pre-hospital environment will decrease the INR. A larger study will be conducted to evaluate whether patient outcomes can be affected by use of thawed plasma in the pre-hospital critical care environment.

Injury, Int. J. Care Injured 42 (2011) 447–459

Contents lists available at ScienceDirect

Injury

journal homepage: www.elsevier.com/locate/injury

Review

Pre-hospital haemostatic dressings: A systematic review

J. Granville-Chapman *, N. Jacobs, M.J. Midwinter

Academic Department of Military Surgery & Trauma, Royal Centre for Defence Medicine, Birmingham, UK

ARTICLE INFO

Article history:
Accepted 28 September 2010

Keywords:
Dressing
Battlefield
Haemostatic
Combat
Prehospital
WoundStat
QuikClot
HemCon
Celox
CombatGauze

ABSTRACT

Background: Uncontrolled haemorrhage is a leading cause of prehospital death after military and civilian trauma. Exsanguination from extremity wounds causes over half of preven military combat deaths and wounds to the anatomical junctional zones provide a particular challenge for first responders. Commercial products have been developed, which claim to outperform standard gauze bandages in establishing and maintaining non-surgical haemostasis. Since 2004, two advanced haemostatic dressing products, HemCon and QuikClot have been widely deployed in military operations. Newer products have since become available which aim to provide more efficient haemostasis than and thus supersede HemCon and QuikClot.

Aim: To conduct a systematic review of clinical and preclinical evidence to compare the relative efficacy and safety of available haemostatic products, which are of relevance to pre-hospital military and civilian emergency medical providers.

Method: An English language literature search was performed, using PubMed® and Web of Knowledge® Databases, with cross-referencing, focussed product searches and communication with product

Lyophilized Plasma

Back to the Future

- Used in WW2: our fathers and grandfathers used it on the Normandy Beaches
- Very portable, very effective
- Problem was that it was pooled plasma
- No available products in the U.S.

MAYO CLINIC
Medical Transport

REVIEW ARTICLE

Tranexamic Acid for Trauma Patients: A Critical Review of the Literature

Andrew P. Cap, MD, PhD, David G. Baer, PhD, Jean A. Orman, MPH, ScD, James Aden, PhD, Kathy Ryan, PhD, and Lorne H. Blackbourne, MD

Background: Tranexamic acid (TXA) is an antifibrinolytic that inhibits both plasminogen activation and plasmin activity, thus preventing clot breakdown rather than promoting new clot formation. TXA has been used around the world to safely control bleeding since the 1960s. A large randomized trial recently conducted in >20,000 trauma patients adds to the large body of data documenting the usefulness of TXA in promoting hemostasis.

Methods: We reviewed the literature describing use of TXA in a variety of settings including trauma.

Results: TXA has been safely used across a wide range of clinical settings to control hemorrhage. The results of a large, randomized, placebo-controlled trial support the use of TXA to treat bleeding trauma patients.

Conclusions: This inexpensive and safe drug should be incorporated into trauma clinical practice guidelines and treatment protocols. Further research on possible alternate mechanisms of action and dosing regimens for TXA should be undertaken. Concurrent to these endeavors, TXA should be adopted for use in bleeding trauma patients because it is the only drug with prospective clinical evidence to support this application.

Key Words: Tranexamic acid, Antifibrinolytic agents, Hemorrhage/drug therapy, Wounds and injuries/complications.

(*J Trauma*. 2011;71: S9–S14)

Army in the conflicts in Iraq and Afghanistan has led to a renewed focus on blood products as the core of hemostatic resuscitation. Hemorrhage remains the leading cause of potentially preventable deaths on the battlefield and as such has been the subject of intensive research and development funding and effort.[3] Fixed-ratio transfusion, emphasizing the early use of plasma and platelets, has been associated with improved outcomes in retrospective studies and has been widely adopted in both civilian and military practice.[4–6] Recent efforts to enhance our understanding of the pathophysiology of trauma and thus facilitate the development of rational, targeted therapies have led to renewed interest in perturbations of the coagulation system. Brohi et al.[7] have shown that ~25% of seriously wounded trauma patients present with abnormal international normalized ratios and that this state is associated with increased morbidity, mortality, and blood product use. Gando et al.[8] have reported similar findings. The molecular underpinning of this state, which has most recently been termed "acute coagulopathy of trauma", appears to involve activation of protein C and the consequent inactivation

TXA

- Cheap
- Safe
- Only drug with prospective clinical evidence to support this application (CRASH-2 Trial)

MAYO CLINIC
Medical Transport

Lancet 2010; 376: 23-32

Effects of tranexamic acid on death, vascular occlusive events, and blood transfusion in trauma patients with significant haemorrhage (CRASH-2): a randomised, placebo-controlled trial

CRASH-2 trial collaborators*

Summary

Background Tranexamic acid can reduce bleeding in patients undergoing elective surgery. We assessed the effects of early administration of a short course of tranexamic acid on death, vascular occlusive events, and the receipt of blood transfusion in trauma patients.

Methods This randomised controlled trial was undertaken in 274 hospitals in 40 countries. 20 211 adult trauma patients with, or at risk of, significant bleeding were randomly assigned within 8 h of injury to either tranexamic acid (loading dose 1 g over 10 min then infusion of 1 g over 8 h) or matching placebo. Randomisation was balanced by centre, with an allocation sequence based on a block size of eight, generated with a computer random number generator. Both participants and study staff (site investigators and trial coordinating centre staff) were masked to treatment allocation. The primary outcome was death in hospital within 4 weeks of injury, and was described with the following categories: bleeding, vascular occlusion (myocardial infarction, stroke and pulmonary embolism), multiorgan failure, head injury, and other. All analyses were by intention to treat. This study is registered as ISRCTN86750102, Clinicaltrials.gov NCT00375258, and South African Clinical Trial Register DOH-27-0607-1919.

Findings 10 096 patients were allocated to tranexamic acid and 10 115 to placebo, of whom 10 060 and 10 067, respectively, were analysed. All-cause mortality was significantly reduced with tranexamic acid (1463 [14·5%] tranexamic acid group *vs* 1613 [16·0%] placebo group; relative risk 0·91, 95% CI 0·85–0·97; p=0·0035). The risk of death due to bleeding was significantly reduced (489 [4·9%] *vs* 574 [5·7%]; relative risk 0·85, 95% CI 0·76–0·96; p=0·0077).

Interpretation Tranexamic acid safely reduced the risk of death in bleeding trauma patients in this study. On the basis of these results, tranexamic acid should be considered for use in bleeding trauma patients.

Lancet 2010; 376: 23-32
Published Online
June 15, 2010
DOI:10.1016/S0140-6736(10)60835-5

See Comment page 3

*Members listed at end of paper

Correspondence to:
Clinical Trials Unit, London School of Hygiene and Tropical Medicine, Keppel Street, London WC1E 7HT, UK
crash@lshtm.ac.uk

Prothrombin Complex Concentrates

PCC

- AKA: “Factor IX Complex Concentrate” to treat Hemophilia B
- Concentrated Vit K related clotting factors (II, VII, IX, X)
- Caveat: Formulations vary—Must be one with Factor VII (European formulation of PCC called Beriplex P/N) contains concentrated doses of all four factors, including factor VII)
- Some preliminary evidence that this may be better than rVIIa or FFP in preventing TIC
- Thrombosis??

Summary

- Hypotensive resuscitation: Give fluid only if patient has altered mental status (not just from TBI) or absent or weak radial pulse
- Give fluid (Hextend 500cc) repeat x1 if patient still in shock
  (?civilian use vs. military use; depends on environment and circumstances: austerity and transport times)
- Overzealous crystalloid appear to be detrimental
- Hemorrhage control is paramount

Summary

- If plasma/PRBCs available: start with plasma, then RBCs in 1:1 ratio (at hospital: 1:1:1 with platelets)
- If not?
  - Consider TXA?
  - Consider PCC (with all of the factors)?

MAYO CLINIC
Medical Transport

FIGURE 12.—Blood transfusion kits being packed at the British Army Blood Supply Depot.

And therefore as a stranger give it welcome.
There are more things in heaven and earth, Horatio,
Than are dreamt of in your philosophy. –Hamlet, Act 1, Scene 5

MAYO CLINIC
Medical Transport


MEDIC ONE

MAYO CLINIC
Medical Transport