Low Volume Resuscitation in Trauma

Dankook University Hospital
Trauma Center

Ye Rim Chang

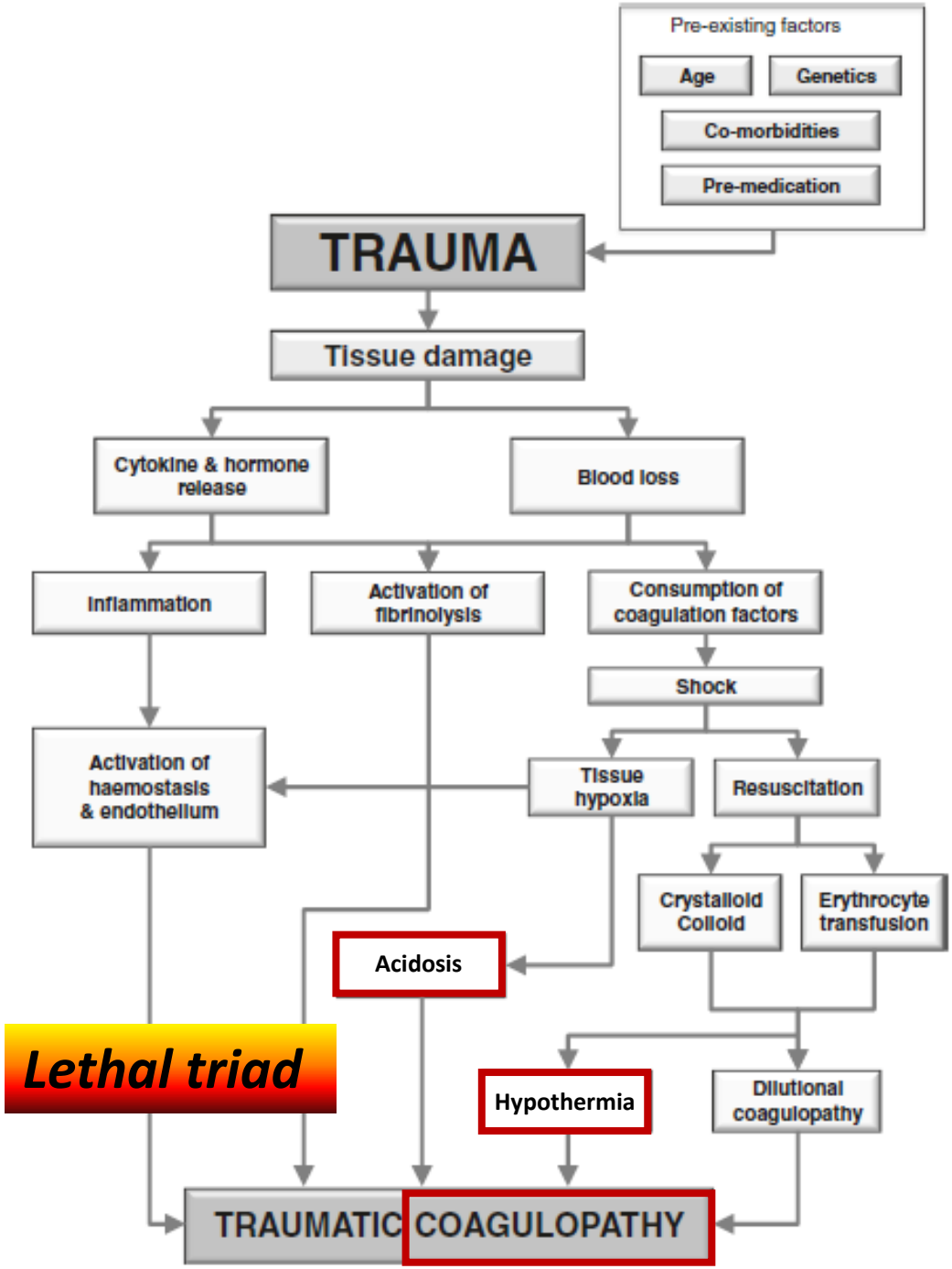
Totally different physiology!

History

- Military resuscitation during 1960s used aggressive crystalloid resuscitation with no predefined transfusion ratio of blood component therapy.
- Fluid administration focused on crystalloid use in an effort to balance inputs and outputs.

This approach failed to address ***acute traumatic coagulopathy*** *in the severely injured patients with hemorrhagic shock.*

J Trauma Acute Care Surg 2013;75:76



Critical Care 2016;20:100

ORIGINAL ARTICLE

Emergency Department Crystalloid Resuscitation of 1.5 L or More is Associated With Increased Mortality in Elderly and Nonelderly Trauma Patients

Eric J. Ley, MD, Morgan A. Clond, PhD, Marissa K. Srour, BS, Moshe Barnajian, MD, James Mirocha, MS, Dan R. Margulies, MD, and Ali Salim, MD

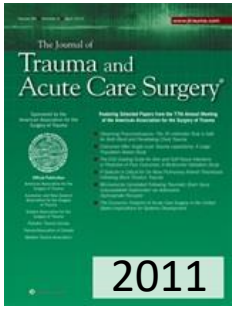


TABLE 3. Estimated Odds Ratios for Various Fluid Resuscitation Volumes in the Nonelderly

Volume (L)	Odds Ratio (95% Wald CI)	*p*
IVF ≥1	1.69 (1.00–2.87)	0.051
IVF ≥1.5	2.09 (1.31–3.33)	0.002
IVF ≥2	2.27 (1.41–3.65)	0.0007
IVF ≥3	2.69 (1.53–4.73)	0.0006

IVF, intravenous fluid (L).

TABLE 5. Odds Ratio for Mortality With Crystalloid Resuscitation in the Elderly

Volume (L)	Odds Ratio (95% Wald CI)	*p*
IVF ≥1	1.10 (0.48–2.49)	0.82
IVF ≥1.5	2.89 (1.13–7.41)	0.027
IVF ≥2	4.57 (1.55–13.53)	0.006
IVF ≥3	8.61 (1.55–47.75)	0.014

IVF, intravenous fluid (L).

TABLE 2. Multivariate Logistic Regression Model for Nonelderly Patients

Risk Factor	Odds Ratio (95% Wald CI)	*p*
ISS ≥16	17.03 (8.34–34.78)	<0.0001
GCS ≤8	16.93 (10.47–27.40)	<0.0001
SBP <90	2.51 (1.28–4.94)	0.0078
IVF ≥1.5	2.09 (1.31–3.33)	0.002

TABLE 4. Multivariate Logistic Regression Model for Elderly Patients

Risk Factor	Odds Ratio (95% Wald CI)	*p*
ISS ≥16	17.15 (5.91–49.79)	<0.0001
GCS ≤8	8.06 (3.31–19.63)	<0.0001
Age ≥80	3.16 (1.35–19.63)	0.008
IVF ≥1.5	2.89 (1.13–7.41)	0.027

PAPER

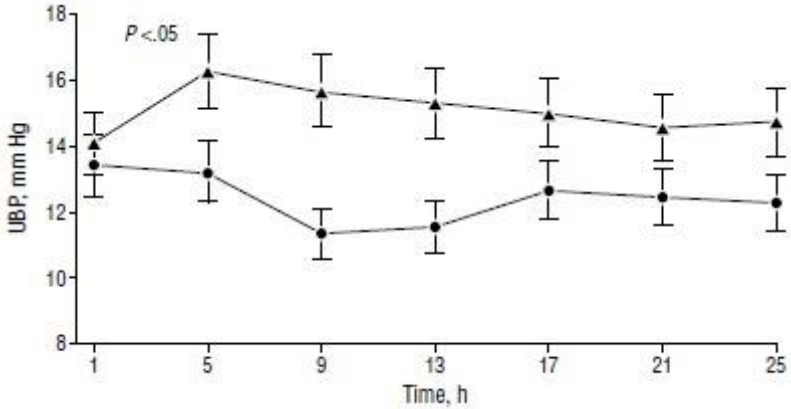
Supranormal Trauma Resuscitation Causes More Cases of Abdominal Compartment Syndrome

Zsolt Balogh, MD; Bruce A. McKinley, PhD; Christine S. Cocanour, MD; Rosemary A. Kozar, MD, PhD; Alicia Valdivia, RN; R. Matthew Sailors, PhD; Frederick A. Moore, MD

2003

- ❖ Indication (n = 156)
  - Multiple organ injury
  - ≥ 6 unit of pRBC in the first 12h
  - Shock

- ❖ Shock resuscitation to achieve oxygen delivery index
  - Supranormal: $DO_2I \geq 600$mL/min
  - Normal: $DO_2I \geq 500$mL/min



Urinary bladder pressure

Table 2. Outcomes of the Supranormal and Normal Resuscitation Cohorts*

	Supranormal Resuscitation (n = 85)	Normal Resuscitation (n = 71)
Intra-abdominal hypertension	42†	20
Abdominal compartment syndrome	16†	8
Multiple organ failure	22†	9
Death	27†	11

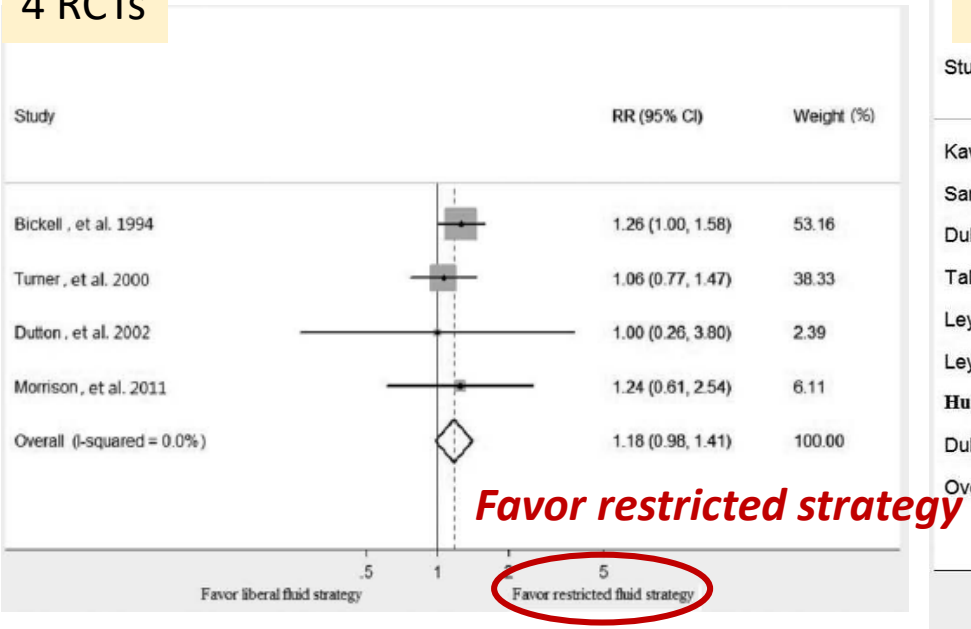
*Data are given as percentage of patients.
†$P<.05$.

Review Articles

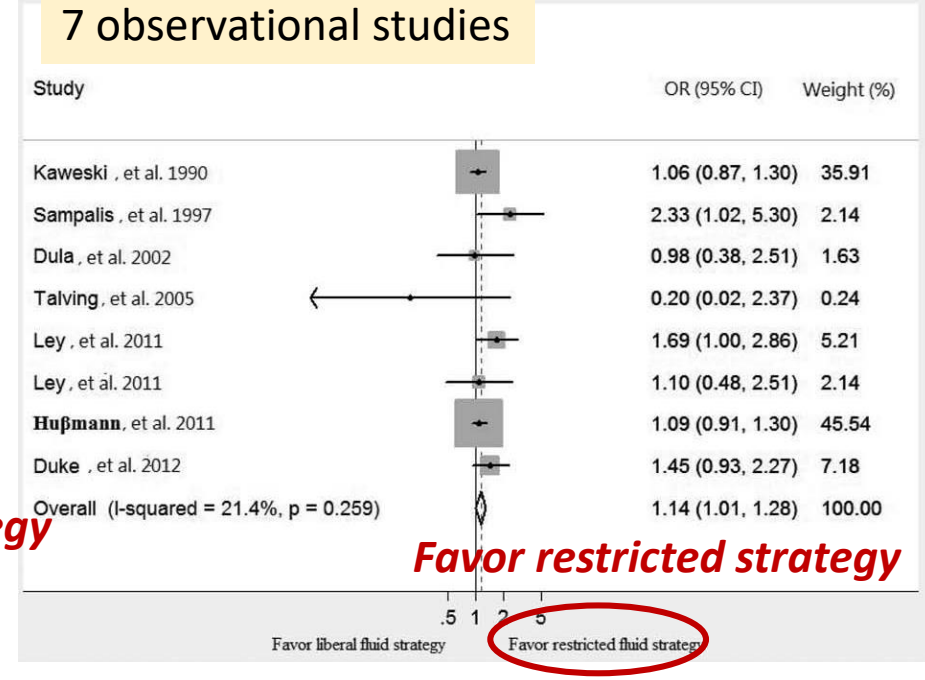
Liberal Versus Restricted Fluid Resuscitation Strategies in Trauma Patients: A Systematic Review and Meta-Analysis of Randomized Controlled Trials and Observational Studies*

Chih-Hung Wang, MD[1]; Wen-Han Hsieh, MS[2]; Hao-Chang Chou, MD[1]; Yu-Sheng Huang, MD[1]; Jen-Hsiang Shen, MS[3]; Yee Hui Yeo, MS[4]; Huai-En Chang, MS[5]; Shyr-Chyr Chen, MD, MBA[1]; Chien-Chang Lee, MD, MSc[6,7]

4 RCTs



7 observational studies



❖ **Forest plot**

Comparison of liberal vs. restricted fluid resuscitation on ***overall mortality***

: delaying fluid resuscitation until arrival at hospital, lower-than-normal BP as a guide for fluid resuscitation

High volume resuscitation may be detrimental.

- ✓ Coagulopathy
- ✓ Abdominal compartment syndrome
- ✓ Multiorgan failure
- ✓ Worse survival

Low Volume Resuscitation

*Is it correct to give **fluid** to these trauma patients ?*

Damage control resuscitation

1. Permissive hypotension

   SBP of 80–90 mmHg or MAP of 50 mmHg

   : To avoid the adverse effects of early aggressive resuscitation

2. Hemostatic resuscitation (Massive transfusion protocol)

   Early use of blood product over isotonic fluid for volume replacement

   : Proactive correction of traumatic coagulopathy

3. Rapid control of hemorrhage (Damage control surgery)

1. Permissive hypotension

Volume 331 OCTOBER 27, 1994 Number 17

IMMEDIATE VERSUS DELAYED FLUID RESUSCITATION FOR HYPOTENSIVE PATIENTS WITH PENETRATING TORSO INJURIES

WILLIAM H. BICKELL, M.D., MATTHEW J. WALL, JR., M.D., PAUL E. PEPE, M.D., R. RUSSELL MARTIN, M.D., VICTORIA F. GINGER, M.S.N., MARY K. ALLEN, B.A., AND KENNETH L. MATTOX, M.D.

Immediate group

Fluid administration if SBP ≤ 90mmHg

vs.

Delayed group

No fluid until arrival

Table 2. Systemic Arterial Blood Pressure and Laboratory Findings on Arrival at the Trauma Center in Patients with Penetrating Torso Injuries, According to Treatment Group.*

VARIABLE	IMMEDIATE RESUSCITATION (N = 309)	DELAYED RESUSCITATION (N = 289)	P VALUE
Systolic blood pressure (mm Hg)	79±46	72±43	0.02
Hemoglobin (g/dl)	11.2±2.6	12.9±2.2	<0.001
Platelet count ($\times 10^{-3}$/mm^3)	274±84	297±88	0.004
Prothrombin time (sec)	14.1±16	11.4±1.8	<0.001
Partial-thromboplastin time (sec)	31.8±19.3	27.5±12	0.007
Systemic arterial pH	7.29±0.17	7.28±0.15	0.46
Serum bicarbonate concentration (mmol/liter)	20±10	20±11	0.82

*Plus–minus values are means ±SD. To convert values for hemoglobin to millimoles per liter, multiply by 0.62.

Table 3. Systemic Arterial Blood Pressure, Heart Rate, and Laboratory Findings at the Time of Initial Operative Intervention in Patients with Penetrating Torso Injuries, According to Treatment Group.*

VARIABLE	IMMEDIATE RESUSCITATION (N = 268)	DELAYED RESUSCITATION (N = 260)	P VALUE
Systolic blood pressure (mm Hg)	112±33	113±30	0.98
Diastolic blood pressure (mm Hg)	57±22	60±21	0.10
Heart rate (beats/min)	102±25	104±23	0.25
Hemoglobin (g/dl)	10.7±5.8	11.5±2.6	<0.001
Platelet count ($\times 10^{-3}$/mm^3)	195±97	198±105	0.99
Systemic arterial pH	7.27±0.16	7.28±0.15	0.75
Serum bicarbonate concentration (mmol/liter)	21±5	20±4	0.39

*Plus–minus values are means ±SD. To convert values for hemoglobin to millimoles per liter, multiply by 0.62.

Volume 331 OCTOBER 27, 1994 Number 17

IMMEDIATE VERSUS DELAYED FLUID RESUSCITATION FOR HYPOTENSIVE PATIENTS WITH PENETRATING TORSO INJURIES

WILLIAM H. BICKELL, M.D., MATTHEW J. WALL, JR., M.D., PAUL E. PEPE, M.D., R. RUSSELL MARTIN, M.D., VICTORIA F. GINGER, M.S.N., MARY K. ALLEN, B.A., AND KENNETH L. MATTOX, M.D.

Immediate group

Fluid administration if SBP ≤ 90mmHg

vs.

Delayed group

No fluid until arrival

Table 5. Outcome of Patients with Penetrating Torso Injuries, According to Treatment Group.

VARIABLE	IMMEDIATE RESUSCITATION	DELAYED RESUSCITATION	P VALUE
Survival to discharge — no. of patients/total patients (%)	193/309 (62)*	203/289 (70)†	0.04
Estimated intraoperative blood loss — ml‡	3127±4937	2555±3546	0.11
Length of hospital stay — days§	14±24	11±19	0.006
Length of ICU stay — days§	8±16	7±11	0.30

Delay of aggressive fluid resuscitation improves outcome.

ORIGINAL ARTICLE

Hypotensive Resuscitation Strategy Reduces Transfusion Requirements and Severe Postoperative Coagulopathy in Trauma Patients With Hemorrhagic Shock: Preliminary Results of a Randomized Controlled Trial

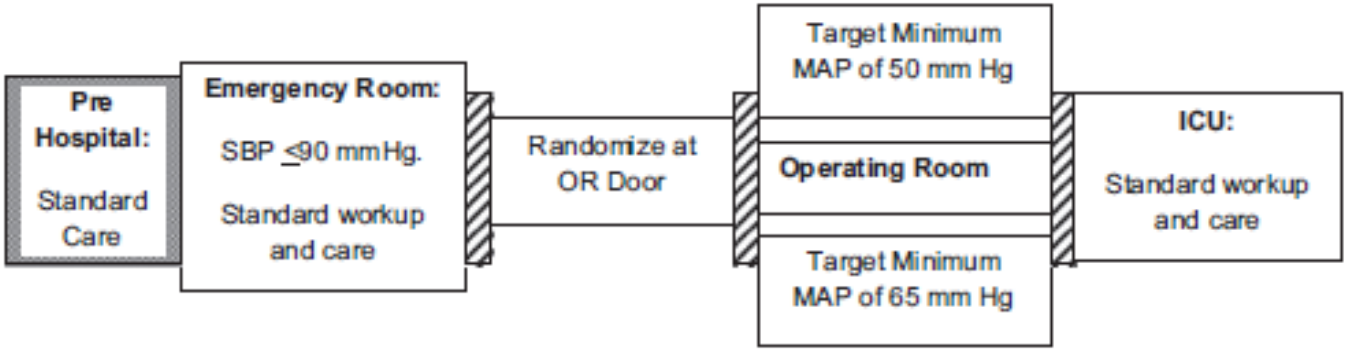


TABLE 9. Timing of Deaths

	MAP = 50 mm Hg (n = 44)	MAP = 65 mm Hg (n = 46)	*p*
Died in OR	5	2	0.26
Died within 24 h of ICU admission	1	8	0.03
Total deaths <24 h	6	10	0.32
Died 1-10 d after ICU admission	2	2	1.00
Died >10 d after ICU admission	2		
Total deaths >24 h	4		
Overall deaths at 30 d	10		

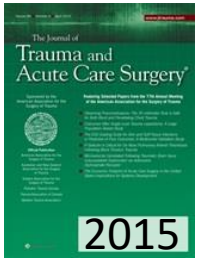
TABLE 11. Postoperative Complications

	MAP = 50 mm Hg (n = 38)	MAP = 65 mm Hg (n = 36)	*p*
Coagulopathy	23 (60.5%)	22 (61.1%)	0.93
Thrombocytopenia	15 (39.5%)	8 (22.2%)	0.09
Anemia	16 (42.1%)	17 (47.2%)	0.97

" Restrictive volume replacement under permissive hypotension "

AAST 2014 PLENARY PAPER

A controlled resuscitation strategy is feasible and safe in hypotensive trauma patients: Results of a prospective randomized pilot trial



Out-of-hospital SBP ≤ 90 mmHg

295 Met eligibility criteria[1]

33 Ineligible but enrolled or
eligible but improperly enrolled
17 No qualifying SBP
8 Severe head injury with GCS ≤ 8
2 Enrolled in the ED[2]
2 CPR prior to opening study kit
1 Spinal cord injury
1 >250ml crystalloid given prior to opening study kit
1 In police custody

136 Not enrolled
116 EMS forgot
4 EMS questioned reliability of SBP
3 Confusion about enrollment criteria
2 Difficulty obtaining/maintaining IV
2 Concern about head injury
2 Not enough time
2 Uncertainty about prisoner status

192 Ran

95 Allocated to **standard resuscitation**

94 Received allocated intervention
1 Treated with controlled resuscitation in the field due to misunderstanding of protocol

97 Allocated to **controlled resuscitation**

97 Received allocated intervention

Standard resuscitation (SR) group

2 L initially & additional fluid
to maintain an SBP ≥ 110 mmHg

Controlled resuscitation (CR) group

250 mL if no radial pulse or SBP <70 mmHg
Additional 250 mL boluses to maintain a radial pulse or an SBP ≥70 mmHg

24h-mortality in blunt trauma subpopulation
: CR group (3.2%) vs. SR group (17.7%)
→ ***Controlled resuscitation may offer an early survival advantage in blunt trauma***

EAST Guideline2017

GUIDELINES

Damage control resuscitation in patients with severe traumatic hemorrhage: A practice management guideline from the Eastern Association for the Surgery of Trauma

Principles of Damage Control Resuscitation

- Avoid/reverse hypothermia
- Minimize blood loss with early hemorrhage control measures during initial evaluation
- Delay resuscitation/target low-normal blood pressure before definitive hemostasis
- Minimize crystalloid administration
- Use MT protocol to ensure sufficient blood products are available in a prespecified ratio
- Avoid delays in surgical or angiographic hemostasis
- Transfuse blood components that optimize hemostasis
- Obtain functional laboratory measures of coagulation (e.g., TEG or TEM) to guide ongoing
- Give pharmacologic adjuncts to safely promote hemostasis

RESEARCH Open Access

The European guideline on management of major bleeding and coagulopathy following trauma: fourth edition

2016

Recommendation 13. ***Tissue oxygenation***

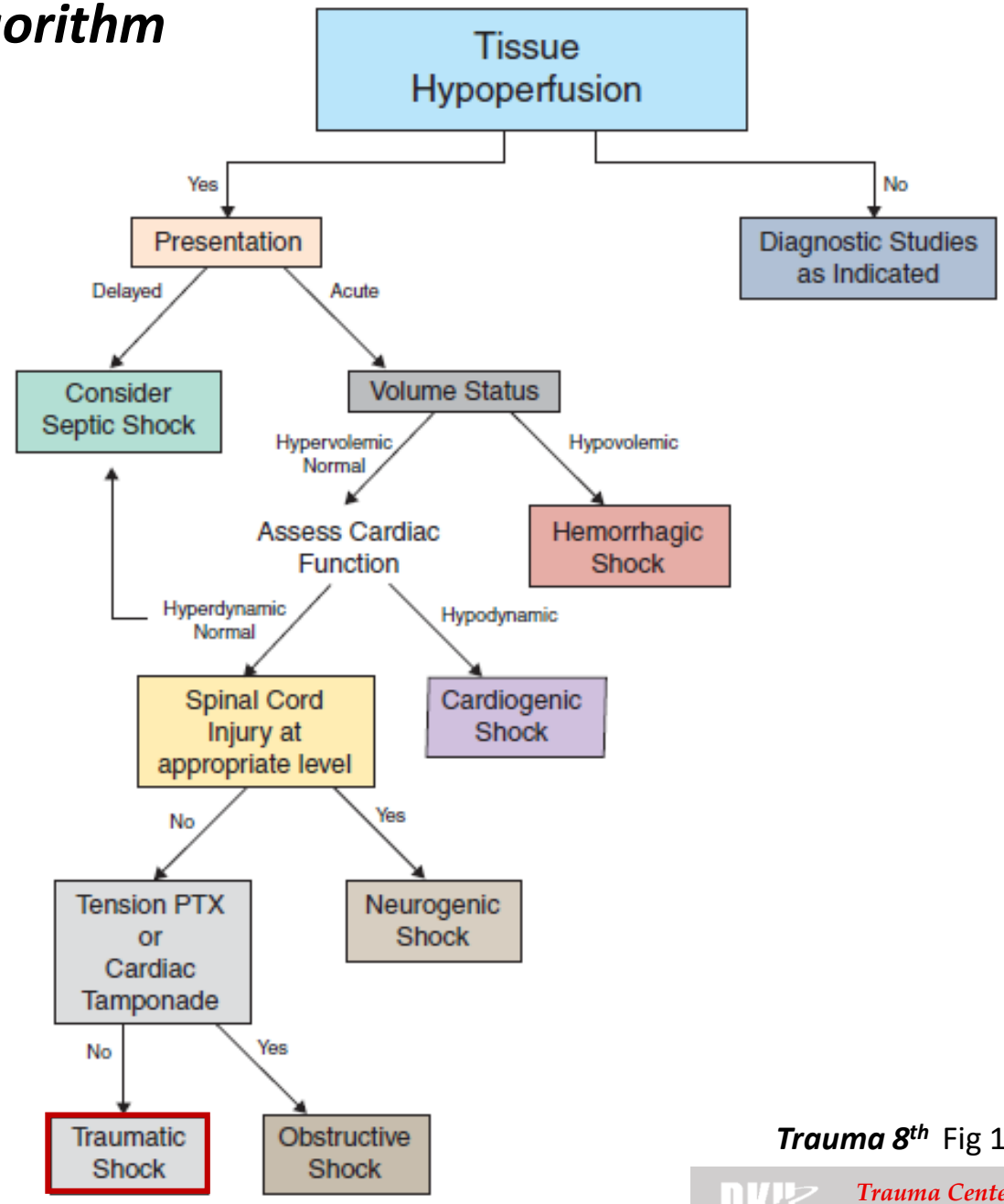
We recommend a target systolic blood pressure of 80–90 mmHg until major bleeding has been stopped in the initial phase following trauma without brain injury. (**Grade 1C**)

Recommendation 14. ***Restricted volume replacement***

We recommend use of a restricted volume replacement strategy to achieve target blood pressure until bleeding can be controlled. (**Grade 1B**)

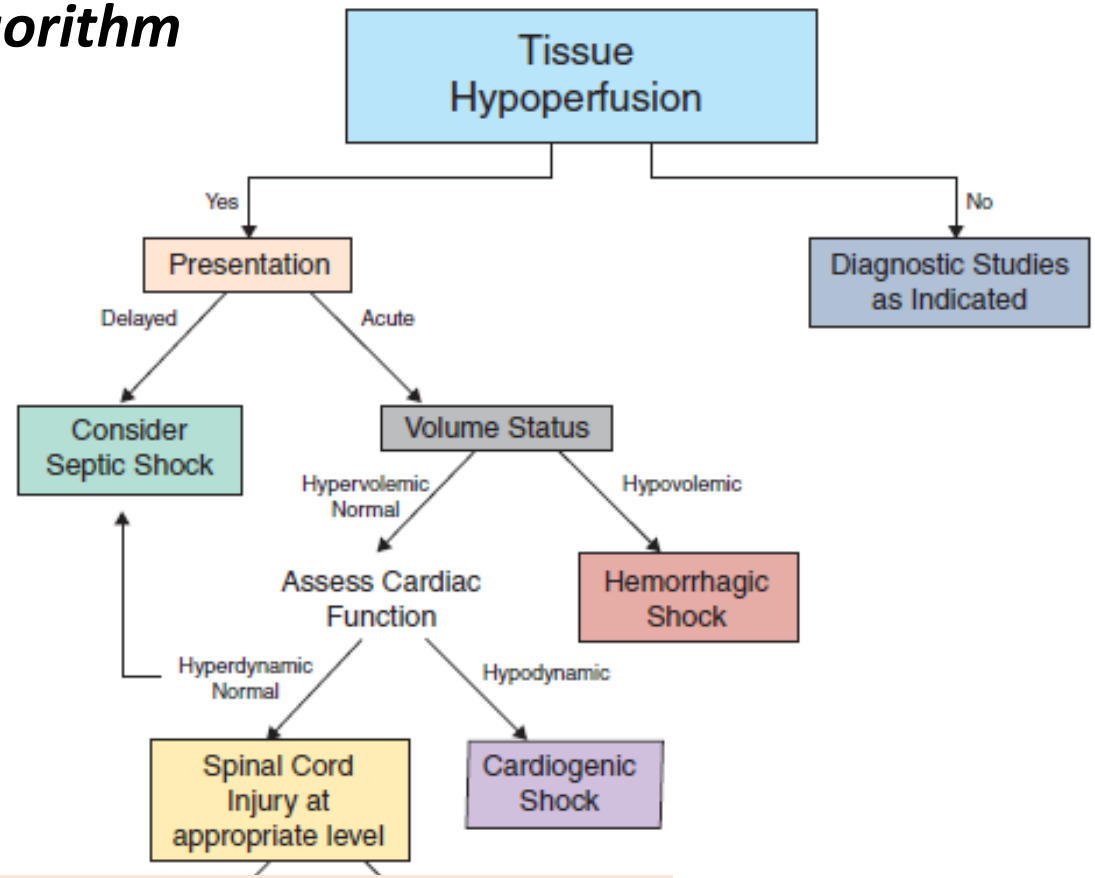
2. Hemostatic resuscitation

Tissue hypoperfusion algorithm



Trauma 8th Fig 12-5

Tissue hypoperfusion algorithm

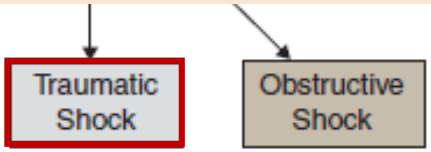


Traumatic shock

: Combination of several insults after injury

eg. small volume of hemorrhage + significant tissue injury,

hypovolemic + neurogenic + obstructive + cardiogenic



Trauma 8th Fig 12-5

Estimated blood loss

TABLE 3.1 Estimated Blood Loss[1] Based on Patient's Initial Presentation				
	CLASS I	CLASS II	CLASS III	CLASS IV
Blood loss (mL)	Up to 750	750–1500	1500–2000	>2000
Blood loss (% blood volume)	Up to 15%	15%–30%	30%–40%	>40%
Pulse rate (BPM)	<100	100-120	120-140	>140
Systolic b pressure	Normal	Normal	Decreased	Decreased
Pulse pressure (mm Hg)	Normal or increased	Decreased	Decreased	Decreased
Respiratory rate	14–20	20–30	30–40	>35
Urine output (mL/hr)	>30	20–30	5–15	Negligible
CNS/mental status	Slightly anxious	Mildly anxious	Anxious, confused	Confused, lethargic
Initial fluid replacement	Crystalloid	Crystalloid	Crystalloid and blood	Crystalloid and blood

ATLS 9th ed.

Response to initial fluid resuscitation

TABLE 3.2 Responses to Initial Fluid Resuscitation[1]

	RAPID RESPONSE	TRANSIENT RESPONSE	MINIMAL OR NO RESPONSE
Vital signs	Return to normal	Transient improvement, recurrence of decreased blood pressure and increased heart rate	Remain abnormal
Estimated blood loss	Minimal (10%–20%)	Moderate and ongoing (20%–40%)	Severe (>40%)
Need for more crystalloid	Low	Low to moderate	Moderate as a bridge to transfusion
Need for blood	Low	Moderate to high	Immediate
Blood preparation	Type and crossmatch	Type-specific	Emergency blood release
Need for operative intervention	Possibly	Likely	Highly likely
Early presence of surgeon	Yes	Yes	Yes

[1]Isotonic crystalloid solution, 2000 mL in adults; 20 mL/kg in children.

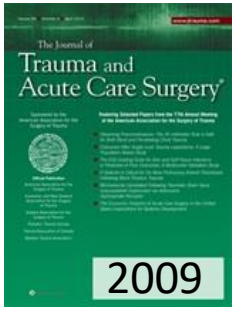
ATLS 9th ed.

Predicting massive transfusion

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

Early Prediction of Massive Transfusion in Trauma: Simple as ABC (Assessment of Blood Consumption)?

Timothy C. Nunez, MD, Igor V. Voskresensky, MD, Lesly A. Dossett, MD, MPH, Ricky Shinall, BS, William D. Dutton, MD, and Bryan A. Cotton, MD



ABC Score

- Penetrating mechanism (0 = no, 1 = yes)
- ED SBP of 90 mm Hg or less (0 = no, 1 = yes)
- ED HR of 120 bpm or greater (0 = no, 1 = yes)
- Positive FAST (0 = no, 1 = yes)

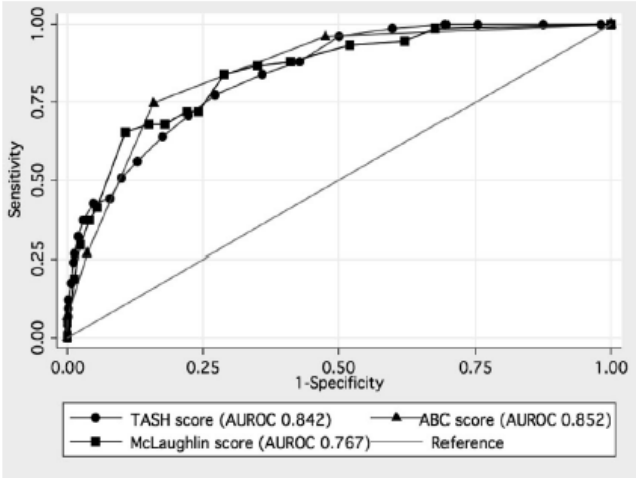


Fig. 3. *AUROC for the three scoring systems.*

→ABC score of 2 or greater was 75% sensitive and 86% specific for predicting massive transfusion.

EAST PLENARY PAPER

Every minute counts: Time to delivery of initial massive transfusion cooler and its impact on mortality

David E. Meyer, MD, Laura E. Vincent, RN, Erin E. Fox, PhD, Terence O'Keeffe, MBChB, Kenji Inaba, MD, Eileen Bulger, MD, John B. Holcomb, MD, *and* Bryan A. Cotton, MD, *Houston, Texas*

Severely injured patients who met criteria for highest-level trauma activation (n= 680)

- Time from patient arrival to MT protocol activation: 9 minutes (median)
- Time from MT activation call to delivery of first cooler: 8 minutes (median)

TABLE 2. Multivariate Regression Predicting 24-h Mortality

	OR	95% CI	*p*
Time to receipt of first cooler, min	1.05	1.01–1.10	0.035
Anatomic injury severity (ISS)	1.03	1.02–1.05	<0.001
Disturbed arrival physiology (w-RTS)	0.69	0.60–0.81	<0.001
Randomization group (1:1:2)	1.69	1.01–2.86	0.047
RI, units	1.12	0.60–2.05	0.719

Resuscitation intensity

TABLE 3. Multivariate Regression Predicting 30-d Mortality

	OR	95% CI	*p*
Time t			
Anator			
Disturl			
Rando			
RI, uni			

ORIGINAL ARTICLE

The Prospective, Observational, Multicenter, Major Trauma Transfusion (PROMMTT) Study

Comparative Effectiveness of a Time-Varying Treatment With Competing Risks

John B. Holcomb, MD; Deborah J. del Junco, PhD; Erin E. Fox, PhD; Charles E. Wade, PhD; Mitchell J. Cohen, MD; Martin A. Schreiber, MD; Louis H. Alarcon, MD; Yu Bai, MD, PhD; Karen J. Brasel, MD, MPH; Eileen M. Bulger, MD; Bryan A. Cotton, MD, MPH; Nena Matijevic, PhD; Peter Muskat, MD; John G. Myers, MD; Herb A. Phelan, MD, MSCS; Christopher E. White, MD; Jiajie Zhang, PhD; Mohammad H. Rahbar, PhD; for the PROMMTT Study Group

2013

Table 3. Multivariable Cox Regression Models Examining the Association of Plasma and Platelet Transfusion Ratios With In-hospital Mortality

	Continuous Transfusion Ratio Variables		Categorical Transfusion Ratio Variables: Low, <1:2	Moderate, ≥1:2 to <1:1		High, ≥1:1	
Characteristic	HR (95% CI)	*P* Value	HR	HR	*P* Value	HR	*P* Value
	Minute 31 to Hour 6 After ED Admission (n = 876)[a]						
Early initial and time-varying plasma:RBC ratios	0.31 (0.16-0.58)	<.001	1 [Reference]	0.42	<.001	0.23	<.001
Early initial and time-varying platelet:RBC ratios	0.55 (0.31-0.98)	.04	1 [Reference]	0.66	.16	0.37	.04
Sum of blood product transfusions	1.05 (1.04-1.06)	<.001	[b]				
Age	1.01 (1.00-1.02)	.03					
Injury Severity Score	1.02 (1.01-1.04)	.001					
Time interval at cohort entry	0.73 (0.63-0.86)	<.001					

Higher plasma and platelet ratios early in resuscitation were associated with decreased mortality in patients who received transfusions of at least 3 units of blood products during the first 24 hours after admission.

Original Investigation

Transfusion of Plasma, Platelets, and Red Blood Cells in a 1:1:1 vs a 1:1:2 Ratio and Mortality in Patients With Severe Trauma

The PROPPR Randomized Clinical Trial

John B. Holcomb, MD; Barbara C. Tilley, PhD; Sarah Baraniuk, PhD; Erin E. Fox, PhD; Charles E. Wade, PhD; Jeanette M. Podbielski, RN; Deborah J. del Junco, PhD; Karen J. Brasel, MD, MPH; Eileen M. Bulger, MD; Rachael A. Callcut, MD, MSPH; Mitchell Jay Cohen, MD; Bryan A. Cotton, MD, MPH; Timothy C. Fabian, MD; Kenji Inaba, MD; Jeffrey D. Kerby, MD, PhD; Peter Muskat, MD; Terence O'Keeffe, MBChB, MSPH; Sandro Rizoli, MD, PhD; Bryce R. H. Robinson, MD; Thomas M. Scalea, MD; Martin A. Schreiber, MS; Deborah M. Stein, MD; Jordan A. Weinberg, MD; Jeannie L. Callum, MD; John R. Hess, MD, MPH; Nena Matijevic, PhD; Christopher N. Miller, MD; Jean-Francois Pittet, MD; David B. Hoyt, MD; Gail D. Pearson, MD, ScD; Brian Leroux, PhD; Gerald van Belle, PhD; for the PROPPR Study Group

2015

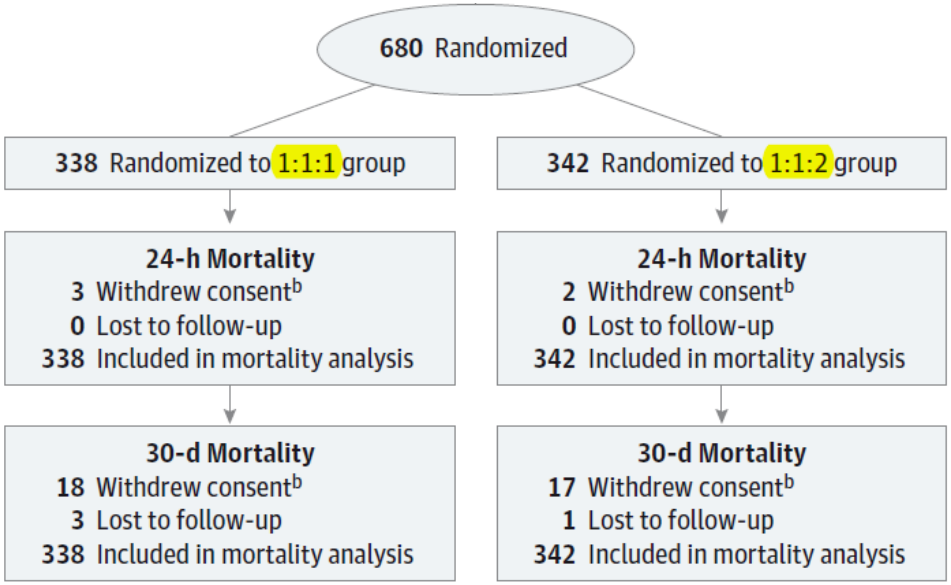


Table 2. Trial Outcomes by Treatment Group

	1:1:1 Group (n = 338)	1:1:2 Group (n = 342)	Difference (95% CI), %	Adjusted RR (95% CI)	*P* Value[a]
24-h Mortality, No. (%)[b]	43 (12.7)	58 (17.0)	−4.2 (−9.6 to 1.1)	0.75 (0.52 to 1.08)	.12
30-d Mortality, No. (%)[b]	75 (22.4)	89 (26.1)	−3.7 (−10.2 to 2.7)	0.86 (0.65 to 1.12)	.26
Achieved hemostasis					
No. (%)	291 (86.1)	267 (78.1)			.006

Original Investigation

Transfusion of Plasma, Platelets, and Red Blood Cells in a 1:1:1 vs a 1:1:2 Ratio and Mortality in Patients With Severe Trauma

The PROPPR Randomized Clinical Trial

John B. Holcomb, MD; Barbara C. Tilley, PhD; Sarah Baraniuk, PhD; Erin E. Fox, PhD; Charles E. Wade, PhD; Jeanette M. Podbielski, RN; Deborah J. del Junco, PhD; Karen J. Brasel, MD, MPH; Eileen M. Bulger, MD; Rachael A. Callcut, MD, MSPH; Mitchell Jay Cohen, MD; Bryan A. Cotton, MD, MPH; Timothy C. Fabian, MD; Kenji Inaba, MD; Jeffrey D. Kerby, MD, PhD; Peter Muskat, MD; Terence O'Keeffe, MBChB, MSPH; Sandro Rizoli, MD, PhD; Bryce R. H. Robinson, MD; Thomas M. Scalea, MD; Martin A. Schreiber, MS; Deborah M. Stein, MD; Jordan A. Weinberg, MD; Jeannie L. Callum, MD; John R. Hess, MD, MPH; Nena Matijevic, PhD; Christopher N. Miller, MD; Jean-Francois Pittet, MD; David B. Hoyt, MD; Gail D. Pearson, MD, ScD; Brian Leroux, PhD; Gerald van Belle, PhD; for the PROPPR Study Group

2015

Table 3. Adjudicated Cause of Death by Treatment Group and Period From Randomization

	First 24 Hours			30 Days		
	No. (%)			No. (%)		
	1:1:1 Group (n = 338)	1:1:2 Group (n = 342)	Difference (95% CI),%[a]	1:1:1 Group (n = 335)	1:1:2 Group (n = 341)	Difference (95% CI), %[a]
Total No. of deaths	43	58		75	89	
Cause of death[b]						
Exsanguination	31 (9.2)	50 (14.6)	−5.4 (−10.4 to −0.5)	36 (10.7)	50 (14.7)	−3.9 (−9.1 to 1.2)
Traumatic brain injury	11 (3.3)	12 (3.5)	−0.3 (−3.2 to 2.7)	27 (8.1)	35 (10.3)	−2.2 (−6.7 to 2.2)
Respiratory, pulmonary contusion, or tension pneumothorax	3 (0.9)	1 (0.3)	0.6 (−0.9 to 2.4)	5 (1.5)	2 (0.6)	0.9 (−0.8 to 3.0)
Sepsis	0	0	0 (−1.1 to 1.1)	1 (0.3)	2 (0.6)	−0.3 (−1.9 to 1.2)
Multiple organ failure	0	0	0 (−1.1 to 1.1)	10 (3.0)	8 (2.3)	0.6 (−2.0 to 3.4)
Type of cardiovascular event						
Stroke	0	1 (0.3)	−0.3 (−1.7 to 0.9)	2 (0.6)	1 (0.3)	0.3 (−1.1 to 1.9)
Myocardial infarction	1 (0.3)	1 (0.3)	0 (−1.4 to 1.4)	1 (0.3)	2 (0.6)	−0.3 (−1.9 to 1.2)
Pulmonary embolism	0	1 (0.3)	−0.3 (−1.7 to 0.9)	0	1 (0.3)	−0.3 (−1.7 to 0.9)
Transfusion-related fatality	0	0	0 (−1.1 to 1.1)	1 (0.3)	0	0.3 (−0.8 to 1.7)

[a] Calculated using exact unconditional methods based on the Farrington-Manning score statistic.

[b] A patient may have had more than 1 cause of death.

Warm fresh whole blood

World War II
Plasma transfusion

ORIGINAL ARTICLE

Fresh whole blood use by forward surgical teams in Afghanistan is associated with improved survival compared to componen therapy without platelets

Shawn C. Nessen, Brian J. Eastridge, Daniel Cronk, Robert M. Craig, Olle Berséus, Richard Ellis Kyle Remick, Jason Seery, Avani Shah, and Philip C. Spinella

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

The Use of Fresh Whole Blood in Massive Transfusion

Thomas B. Repine, MD, Jeremy G. Perkins, MD, David S. Kauvar, MD, and Lorne Blackborne, MD

Fluids

- Which type of fluids ?
- ~~How much ?~~
- How fast ?
- Monitoring

1. Which type of fluids ?

- Trauma 8th ed. 2017
- ATLS 9th ed. 2012
- KTAT (Korean Trauma Assessment and Treatment) 2nd ed.
- European guidelines on management of bleeding following major trauma 2016

: Isotonic balanced crystalloids

Warmed fluids

0.9 % sodium chloride

- Aggravation of metabolic acidosis
- Relevant dilution of blood components

→ Aggravation of coagulopathy / hypothermia

Lethal triad

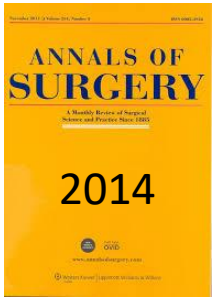
1) Balanced solution

RANDOMIZED CONTROLLED TRIAL

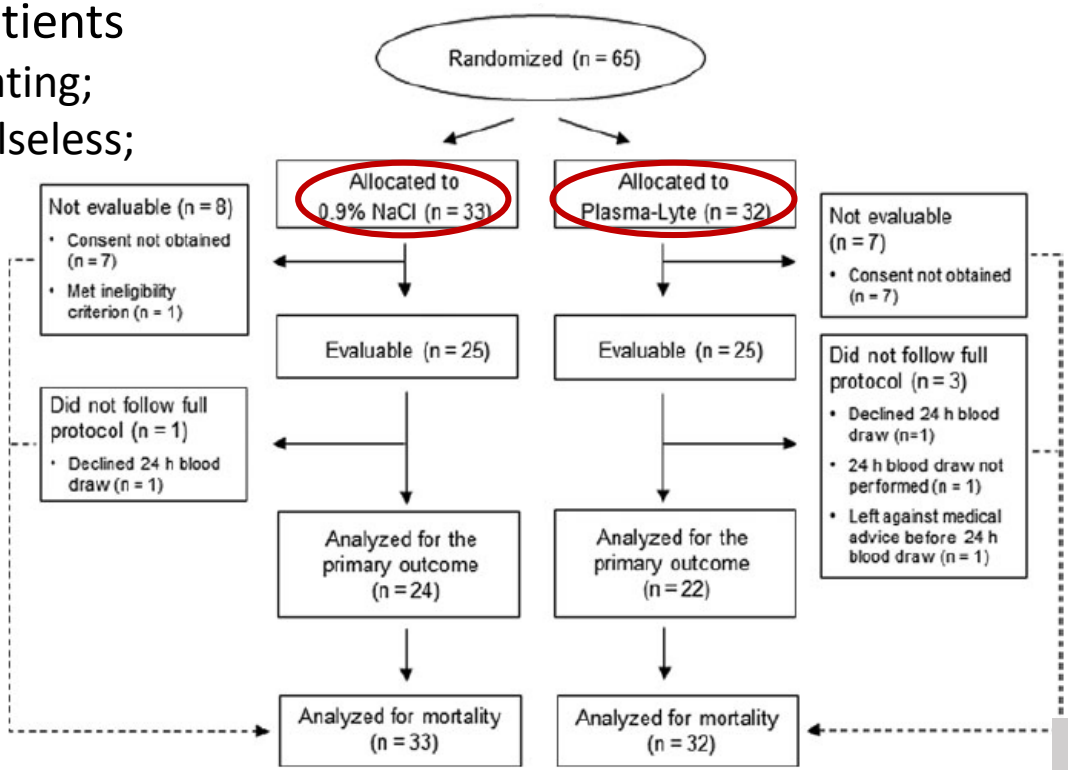
Saline Versus Plasma-Lyte A in Initial Resuscitation of Trauma Patients

A Randomized Trial

Jason B. Young, MD, PharmD, Garth H. Utter, MSc, MD, Carol R. Schermer, MD, MPH, Joseph M. Galante, MD, Ho H. Phan, MD, Yifan Yang, MD, Brock A. Anderson, MD, and Lynette A. Scherer, MD



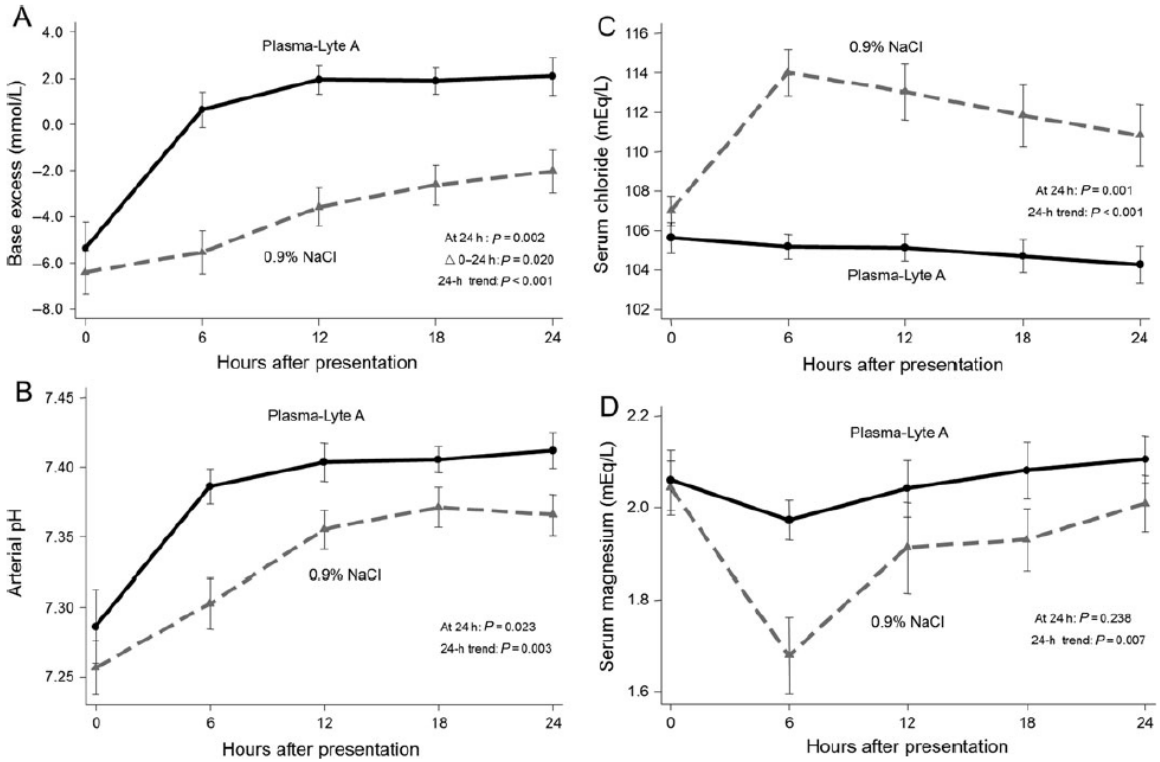
Severely injured patients
- GCS < 9 or deteriorating;
- SBP < 90 mmHg; pulseless;
- Need for intubation



1) Balanced solution

- 0.9% NaCl (n=33) vs. Plasma-Lyte A (n=32)

Improved acid-base status
Less hyperchloremia at 24 hours post-injury



2) Colloids in trauma

ORIGINAL ARTICLE

A Comparison of Albumin and Saline for Fluid Resuscitation in the Intensive Care Unit

The SAFE Study Investigators*

2004

Albumin (n = 3497) vs. saline (n = 3500)
Trauma patients 17%

Table 3. Primary and Secondary Outcomes.*

Outcome	Albumin Group	Saline Group	Relative Risk (95% CI)	Absolute Difference (95% CI)	P Value
Death within 28 days according to subgroup — no./total no. (%)					
Patients with trauma	81/596 (13.6)	59/590 (10.0)	1.36 (0.99 to 1.86)		0.06
Patients with severe sepsis	185/603 (30.7)	217/615 (35.3)	0.87 (0.74 to 1.02)		0.09
Patients with acute respiratory distress syndrome	24/61 (39.3)	28/66 (42.4)	0.93 (0.61 to 1.41)		0.72

Mortality in TBI patients:
Albumin (24.5 %) vs. saline (15.1 %) (RR 1.62; ***p*=0.009**)

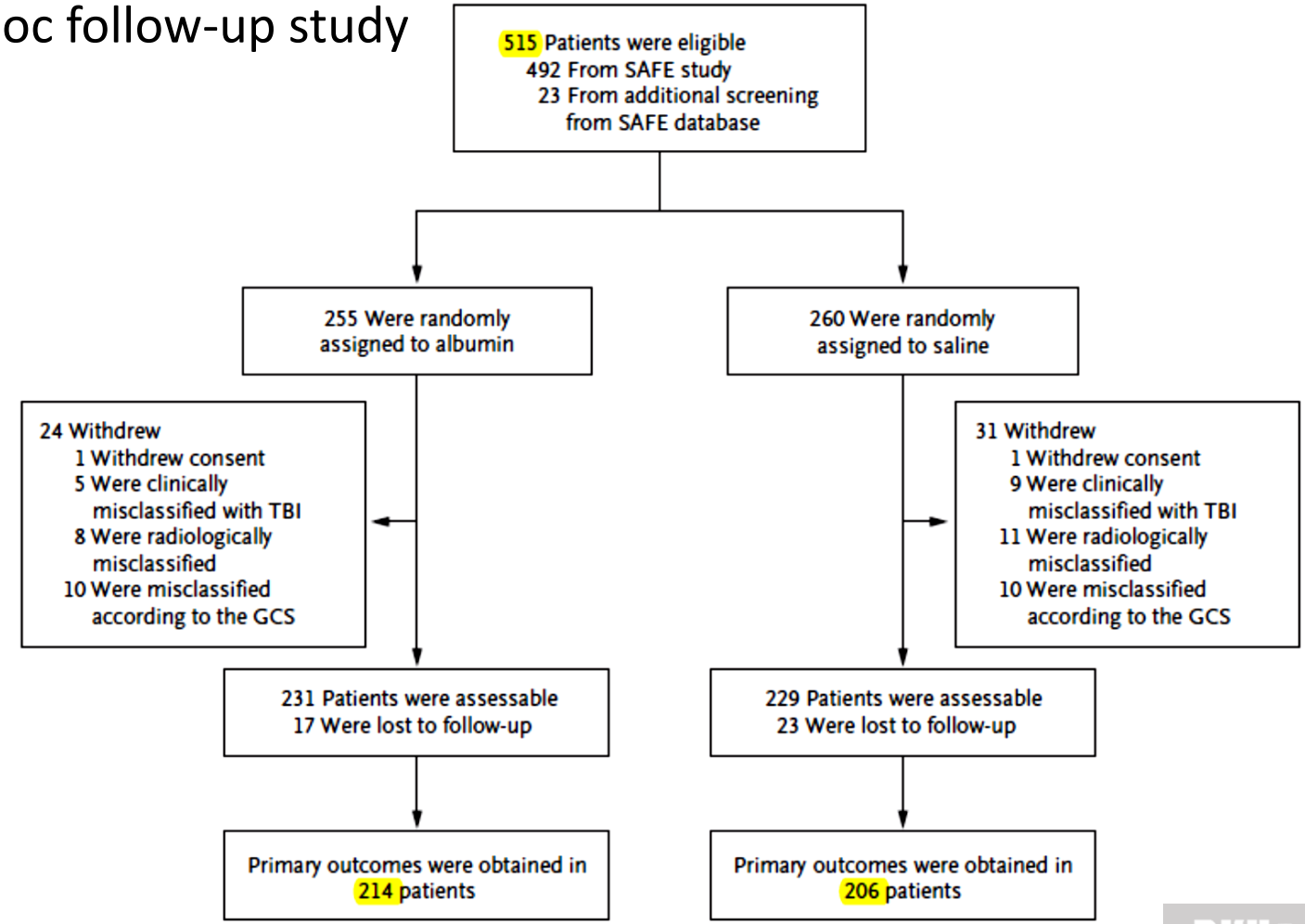
ORIGINAL ARTICLE

Saline or Albumin for Fluid Resuscitation in Patients with Traumatic Brain Injury

The SAFE Study Investigators*

2007

Post hoc follow-up study



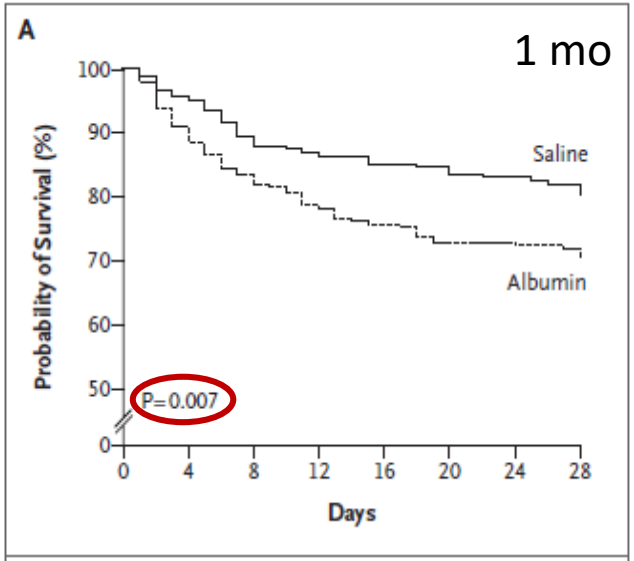
ORIGINAL ARTICLE

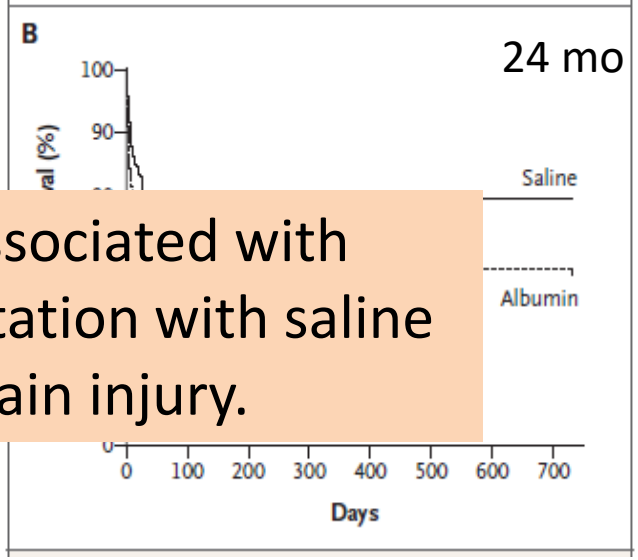
Saline or Albumin for Fluid Resuscitation in Patients with Traumatic Brain Injury

The SAFE Study Investigators*

Table 3. Primary and Secondary Outcomes.*

Outcome	Albumin Group	Saline Group	Relative Risk (95% CI)	P Value
All patients				
Deaths — no./total no. (%)				
Within 28 days	61/231 (26.4)	36/229 (15.7)	1.68 (1.16–2.43)	0.005
Within 6 mo	68/221 (30.8)	40/217 (18.4)	1.67 (1.18–2.35)	0.003
Within 12 mo	69/220 (31.4)	40/216 (18.5)	1.69 (1.20–2.38)	0.002
Within 24 mo	71/214 (33.2)	42/206 (20.4)	1.63 (1.17–2.26)	0.003
Favorable score on the GOSe at 24 mo	96/203 (47.3)	120/198 (60.6)	0.78 (0.65–0.94)	0.007
Survivors at 24 mo	96/132 (72.7)	120/156 (76.9)	0.95 (0.83–1.08)	0.41
Patients with a GCS score of 3–8				
Deaths — no./total no. (%)				
Within 28 days	55/160 (34.4)	30/158 (18.9)	1.83 (1.23–2.71)	0.002
Within 6 mo	60/154 (38.9)	32/149 (21.5)	1.81 (1.26–2.61)	0.001
Within 12 mo	61/153 (39.9)	32/149 (21.5)	1.86 (1.29–2.67)	0.001
Within 24 mo	61/146 (41.8)	32/144 (22.2)	1.88 (1.31–2.70)	<0.001
Favorable score on the GOSe at 24 mo	51/139 (36.7)	77/140 (55.0)	0.67 (0.51–0.87)	0.002
Survivors at 24 mo	51/78 (65.4)	77/108 (71.3)	0.92 (0.75–1.12)	0.39
Patient				
Deaths				
Wit				
Wit				
Wit				
Wit				
Favorable score on the GOSe at 24 mo	36/49 (73.5)	24/36 (66.7)	1.10 (0.83–1.47)	0.51
Survivors at 24 mo	36/44 (81.8)	24/33 (72.7)	1.13 (0.88–1.43)	0.34





Fluid resuscitation with ***albumin*** was associated with ***higher mortality*** rates than was resuscitation with saline in critically ill patients with traumatic brain injury.

ORIGINAL ARTICLE

Hydroxyethyl Starch or Saline for Fluid Resuscitation in Intensive Care

John A. Myburgh, M.D., Ph.D., Simon Finfer, M.D., Rinaldo Bellomo, M.D., Laurent Billot, M.Sc., Alan Cass, M.D., Ph.D., David Gattas, M.D., Parisa Glass, Ph.D., Jeffrey Lipman, M.D., Bette Liu, Ph.D., Colin McArthur, M.D., Shay McGuinness, M.D., Dorrilyn Rajbhandari, R.N., Colman B. Taylor, M.N.D., and Steven A.R. Webb, M.D., Ph.D., for the CHEST Investigators and the Australian and New Zealand Intensive Care Society Clinical Trials Group*

2012

6% HES (n = 3358) vs. 0.9% saline (n =3384)

Table 1. Characteristics of the Patients at Baseline.*

Predefined subgroups — no./total no. (%)
RIFLE criteria for acute kidney injury‡
Sepsis
Trauma
Traumatic brain injury
APACHE II score ≥25
Receipt of HES before randomization

B Subgroup Analyses

Subgroup	HES	Saline	Risk Ratio (95% CI)	P Value
	no. of events/total no. (%)			
Death from any cause at 90 days	597/3315 (18.0)	566/3336 (17.0)	1.06 (0.96–1.18)	0.26
RIFLE criteria at randomization				0.66
Presence of acute renal injury	99/519 (19.1)	95/503 (18.9)	1.01 (0.78–1.30)	0.94
Absence of acute renal injury	132/919 (14.4)	118/896 (13.2)	1.09 (0.87–1.37)	0.46
Sepsis at randomization				0.78
Diagnosis on admission	248/976 (25.4)	224/945 (23.7)	1.07 (0.92–1.25)	0.38
No diagnosis on admission	349/2337 (14.9)	342/2383 (14.4)	1.04 (0.91–1.19)	0.57
Trauma				0.90
Yes	18/258 (7.0)	18/263 (6.8)	1.02 (0.54–1.91)	0.95
No	579/3057 (18.9)	548/3073 (17.8)	1.06 (0.96–1.18)	0.26
Traumatic brain injury				0.31
Yes	1/27 (3.7)	3/30 (10.0)	0.37 (0.04–3.35)	0.35
No	594/3269 (18.2)	560/3287 (17.0)	1.07 (0.96–1.18)	0.23

***No difference** in 90-day mortality in trauma subgroup.*

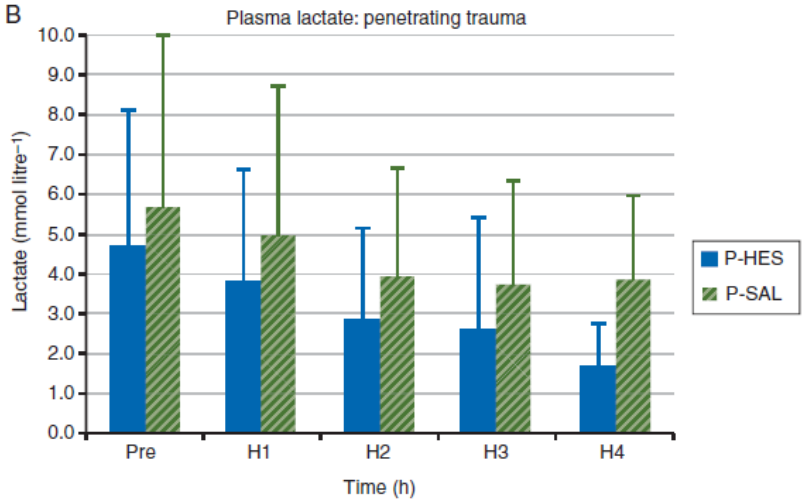
Resuscitation with hydroxyethyl starch improves renal function and lactate clearance in penetrating trauma in a randomized controlled study: the FIRST trial (Fluids in Resuscitation of Severe Trauma)

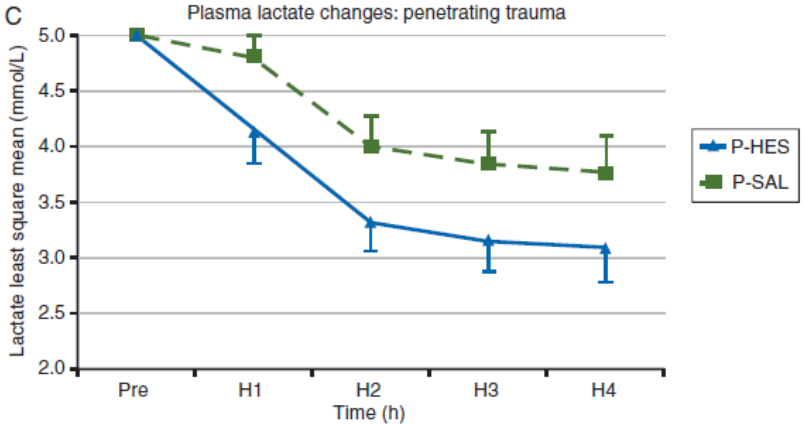
M. F. M. James[1]*, W. L. Michell[2], I. A. Joubert[1], A. J. Nicol[2], P. H. Navsaria[2] and R. S. Gillespie[1]

[1] Department of Anaesthesia and [2] Department of Surgery, Groote Schuur Hospital and Faculty of Health Sciences, University of Cape Town, Anzio Road, Observatory, Cape Town, Western Cape 7925, South Africa

2011

Trauma patients (penetrating, n=67; blunt, n=42)





Resuscitation with hydroxyethyl starch improves renal function and lactate clearance in penetrating trauma in a randomized controlled study: the FIRST trial (Fluids in Resuscitation of Severe Trauma)

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2011

Table 6 Distribution of renal outcomes in blunt and penetrating trauma by fluid group. *P=0.043 for the difference between P-HES and P-SAL. †P=0.018 for differences between P-HES and P-SAL

	P-HES		P-SAL		B-HES		B-SAL	
	No	Yes	No	Yes	No	Yes	No	Yes
Risk	35*	1 (3%)	25	6 (19%)	13	7 (35%)	16	6 (27%)
Injury	36†	0 (0%)	26	5 (16%)	16	4 (20%)	19	3 (14%)
Dialysis	36	0	29	2 (6%)	18	2 (8%)	21	1 (5%)

→ **HES** (130/0.4) provided significantly **better lactate clearance** and **less renal injury** than saline.

European guideline 2016

We suggest that the use of colloids be ***restricted*** due to the adverse effects on hemostasis. (Grade 2C)

3) Hypertonic saline

- **PROS**
  - Redistribution of extracellular & intracellular water into the intravascular space

    → Volume effect exceeding the amount of infused volume
  - Limited edema formation
  - Marked reduction of baggage load for rescue forces
  - Anti-inflammatory* and immunomodulatory effects†

*Ann Surg 2007; 245:635
†Ann Surg 2006;243:47

- **CONS**
  - Capillary pressure ↑ → blood loss↑or reactivate bleeding

- **RCT**, 209 Blunt trauma patients‡
  - 250 ml 7.5 % hypertonic saline vs. 6 % dextran 70
  - no significant difference in organ failure and in ARDS-free survival

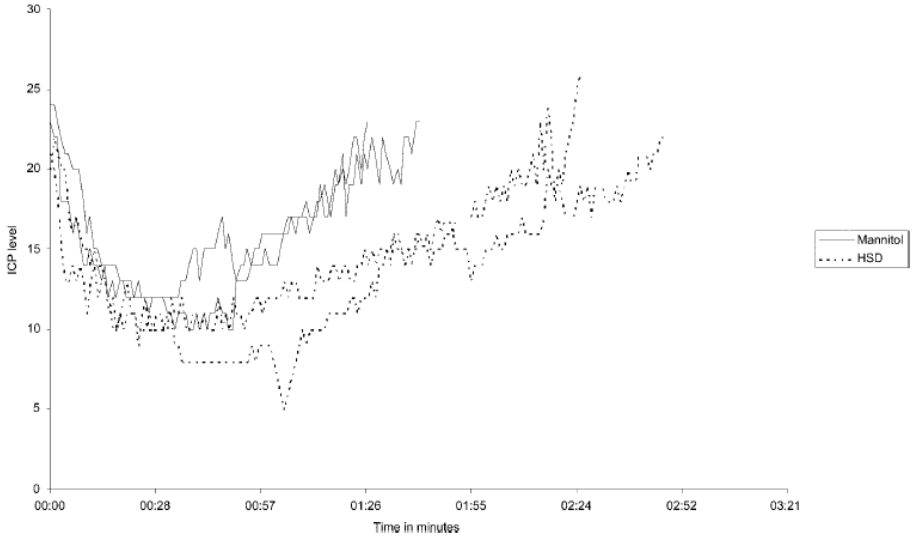
‡ *Arch Surg.* 2008;143(2):139

Hypertonic saline for traumatic brain injury

- Medical therapies for brain injury

  : Temporary hyperventilation, mannitol, hypertonic saline, barbiturates, and anticonvulsants.

- RCT, 2005
  - 9 patients
  - Hypertonic saline vs. dextran + 20% mannitol



: Hypertonic saline was more effective in reducing ICP

Crit Care Med. 2005;33(1):196

Hypertonic saline for traumatic brain injury

- RCT, 2004
  - Prehospital setting
  - 250mL hypertonic solution (HTS) vs. Ringer's lactate
  - **No difference** in **neurological function** at 6 months

- RCT, 2010
  - Prehospital setting, 1282 patients
  - 250 mL HTS / HTS + dextran vs. 0.9% saline

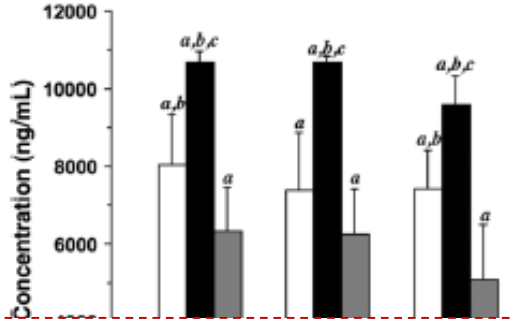
- RCT, 2011
  - Prehospital setting, 853 patients
  - 250 mL HTS vs. HTS + dextran vs. 0.9% saline

No survival difference

Crit Care Med. 2005;33(1):196
JAMA. 2010;304(13):1455
Ann Surg. 2011;253(3):431

Hypertonic saline for traumatic brain injury

- RCT, 2015
  - Prehospital setting
  - n = 34
  - 250 mL HTS vs. HTS + dextran vs. 0.9% saline
  - Hypertonic saline ***interfere coagulation***



European guideline 2016

The evidence suggests that hypertonic saline solutions will neither improve survival nor improve neurological outcome after TBI.

Shock. 2015;44(1):25

2. How fast ?

Current guidelines for resuscitation of shock

- Rapid normalization of blood pressure may be the general consensus when the bleeding is controlled or ongoing blood loss is absent.
- No specific guideline for the speed of reperfusion

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Gradual and stepwise increase of blood pressure in hemorrhagic shock: Mimicking ischemic post-conditioning

Jae Hyuk Lee, Kyuseok Kim *, You Hwan Jo, Kyeong Won Kang [1], Joong Eui Rhee, Chan Jong Park, Joonghee Kim, Heajin Chung

ORIGINAL ARTICLE

Blood pressure–targeted stepwise resuscitation for hemorrhagic shock in rats

Jae Hyuk Lee, MD, PhD, Kyuseok Kim, MD, PhD, You Hwan Jo, MD, PhD, Min A Kim, MD, PhD, Kyoung-Bun Lee, MD, PhD, Joong Eui Rhee, MD, PhD, Ah-Reum Doo, PhD, Min Ji Lee, BSc, Chan Jong Park, MD, Joonghee Kim, MD, *and* Heajin Chung, MD, *Seoul, Korea*

Med Hypotheses. 2013;81(4):701
J Trauma Acute Care Surg. 2014;76(3):771

3. Monitoring

- Lactate
  - produced by anaerobic glycolysis
  - Indirect marker of oxygen debt, tissue hypoperfusion, and the severity of hemorrhagic shock
  - Diagnostic & prognostic marker since 1960s

- Base deficit
  - Classification*

Mild	Moderate	Severe
-3 to -5 mEq/L	-6 to -9 mEq/L	< -10 mEq/L

  - Better prognostic marker than pH †

*J Trauma. 1996;41(5):769
† J Trauma. 1998;44(1):114

3. Monitoring

- **Base deficit**
  - Better prognostic marker than pH †

Base deficit and pH clearance

Group	Admission	2 hours	4 hours	8 hours	16 hours	24 hours	48 hours
BD_survive	−7.0 ± 0.1	−6.3 ± 0.4	−5.4 ± 0.3	−4.2 ± 0.4	−1.2 ± 0.3	0.6 ± 0.3	2.6 ± 0.2
BD_died	−7.3 ± 0.1	−9.8 ± 0.9	−7.7 ± 0.9	−6.2 ± 0.8	−3.5 ± 0.9	−1.9 ± 0.9	−0.3 ± 0.9
p value	0.02	0.001	0.004	0.011	0.002	0.001	0.001
pH_survive	7.32 ± .00	7.35 ± .01	7.37 ± .01	7.38 ± .01	7.41 ± .01	7.43 ± .01	7.44 ± .01
pH_died	7.31 ± .01	7.29 ± .02	7.33 ± .02	7.37 ± .02	7.40 ± .02	7.43 ± .02	7.43 ± .02
p value	NS	0.004	NS	NS	NS	NS	NS

NS, not significant.

Group	Admission	2 hours	4 hours	8 hours	16 hours	24 hours	48 hours
BD_survive	−14.1 ± 0.4	−8.7 ± 0.6	−7.5 ± 0.6	−4.9 ± 0.5	−1.7 ± 0.4	0.4 ± 0.5	2.6 ± 0.4
BD_died	−15.9 ± 0.5	−13.6 ± 1.0	−10.0 ± 1.1	−7.1 ± 1.1	−5.4 ± 1.2	−3.4 ± 1.2	−1.1 ± 0.8
p value	0.002	0.001	0.026	0.032	0.001	0.001	0.001
pH_survive	7.18 ± .01	7.29 ± .01	7.32 ± .01	7.36 ± .01	7.40 ± .01	7.43 ± .01	7.45 ± .01
pH_died	7.12 ± .01	7.20 ± .02	7.29 ± .03	7.34 ± .02	7.36 ± .02	7.39 ± .02	7.43 ± .01
p value	0.001	0.002	NS	NS	0.024	0.041	NS

NS, not significant.

J Trauma. 1998;44(1):114

3. Monitoring

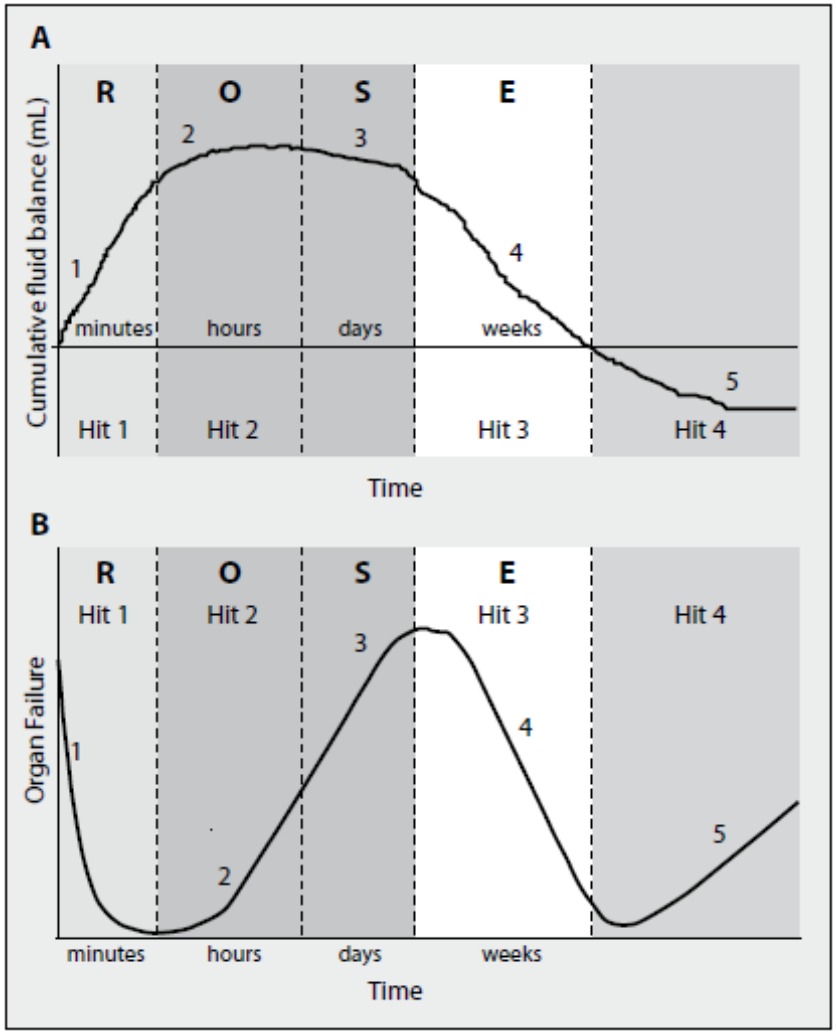
Fluid overload, de-resuscitation, and outcomes in critically ill or injured patients: a systematic review with suggestions for clinical practice

Manu L.N.G. Malbrain[1], Paul E. Marik[2], Ine Witters[1], Colin Cordemans[1], Andrew W. Kirkpatrick[3], Derek J. Roberts[3,4], Niels Van Regenmortel[1]

Analogy between
the four D's of antibiotics and fluid therapy

Drug
Dosing
Duration
De-escalation

Resuscitation
Optimization
Stabilization
Evacuation

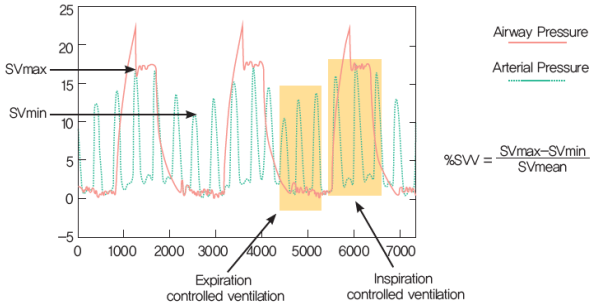


Arterial Pressure Waveform Analysis

PiCCO$_2$ (Pulsion Medical Systems)

LiDCOplus/LiDCOrapid (LiDCO limited)

FloTrac Vigileo (Edwards Life Sciences)



TransPulmonary ThermoDilution methods

PiCCO (Pulsion Medical Systems)

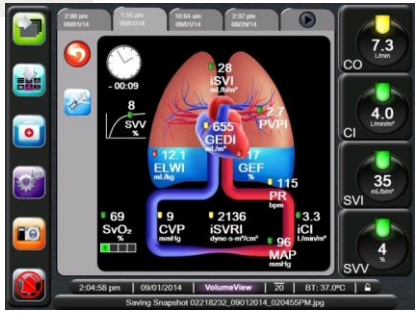
Volume View (Edwards Life Sciences)

Lithium Dilution Technique

LiDCO (LiDCO limited)

Ultrasound Indicator Dilution

COstatus (Transonic Systems, Inc.)



EAST 2017 PLENARY PAPER

Monitoring modalities and assessment of fluid status: A practice management guideline from the Eastern Association for the Surgery of Trauma

Summary of recommendations

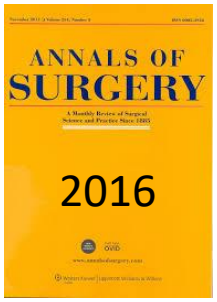
In surgical patients being evaluated or treated for shock, we conditionally recommend a protocol that includes ***Focused ultrasound*** be utilized versus a standard protocol to predict **fluid responsiveness**, to reduce **complications** and **organ failures** and to reduce **mortality**.

In surgical patients being evaluated or treated for shock, we conditionally recommend a protocol that includes ***arterial waveform analysis derived variables*** be utilized versus a standard protocol to predict **fluid responsiveness**, to reduce **complications** and **organ failures** and to reduce **mortality**.

RANDOMIZED CONTROLLED TRIAL

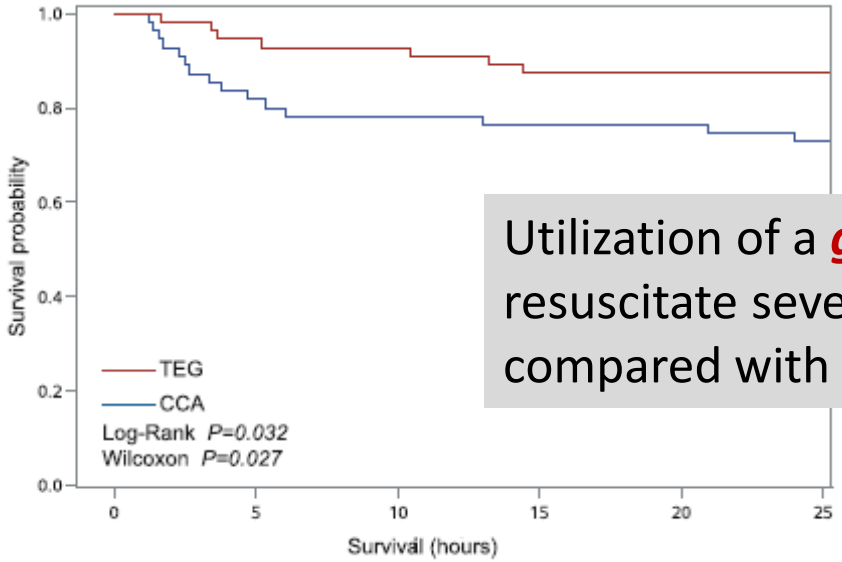
Goal-directed Hemostatic Resuscitation of Trauma-induced Coagulopathy

A Pragmatic Randomized Clinical Trial Comparing a Viscoelastic Assay to Conventional Coagulation Assays



Injured patients from an academic level-1 trauma center meeting criteria for MTP activation

- Viscoelastic assay thrombelastography (TEG = 56)
- Conventional coagulation assays (CCA = 55)



Utilization of a ***goal-directed, TEG-guided MTP*** to resuscitate severely injured patients improves ***survival*** compared with an MTP guided by CCA.

Summary & Conclusions

- **In hemorrhagic shock,**
  - Restrictive volume replacement under permissive hypotension
  - Early use of blood product with balanced ratio
  - Followed by rapid control of bleeding

- **Warmed isotonic *balanced* crystalloids**
- Restricted use of colloids
- Hypertonic saline has no benefit.
- ***High volume resuscitation may be detrimental !***

- **Focused USG & arterial waveform analysis derived variables** can be utilized for monitoring.