

Damage Control Resuscitation in Prehospital and Austere Environments



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Disclosure and Disclaimer



NM
SCHOOL OF MEDICINE
DEPARTMENT OF EMERGENCY MEDICINE
THE INSTITUTE OF
PRE-HOSPITAL CARE

STERIS

STERIS

PHILIPS

Overview

Case

The Triad (or the Diamond?): What We're
Up Against

Prehospital Damage Control

Patient Presentation

- 22 year old male, dismounted patrol
- RPG impact near by
- Shrapnel wounds to LLE, groin area, and lower abdomen
- TQ on LLE, on a litter, mylar blanket



Vital Signs

BP – 82/40

RR – 22

HR – 142

CAO x 4, but in pain

THE OLD WAY

20 - 30+ cc/kg crystalloid bolus

Oxygen, monitor, rush to hospital/CSH

Additional crystalloid during initial stabilization

Patient tailored approach to resuscitation

Definitive surgical care





***ADVANCES IN
TRAUMA CARE FROM
OEF/OIF***

A New Trauma Paradigm

What we are up
against...

Acidosis

DEATH

Hypothermia

Coagulopathy

LETHAL DIAMOND – the Role of Ca^{2+}

Hypothermia

- Causes decreased liver metabolism of citrate
- Citrate not metabolized in the liver binds Ca^{2+} leading to less available in the blood

Acidosis

- Low Ca^{2+} levels associated with lower pH
- Lower blood pH prolongs clot formation time



Coagulopathy

- Ca^{2+} in the plasma is a necessary co-factor in the clotting cascade

Hypocalcemia

- Ca^{2+} drops due to blood loss
- Transfusion exacerbates further

*Normal Blood Ca^{2+} in an healthy adult
4.64 to 5.28 mg/dL or 1.20-1.40 mmol/L

Ditzel RM, et al. A review of transfusion- and trauma-induced hypocalcemia: Is it time to change the lethal triad to the lethal diamond? *J Trauma Acute Care Surg.* 2020.

Damage Control Resuscitation

Damage Control Resuscitation



HEMOSTATIC RESUSCITATION

+

TARGETED HEMODYNAMICS

+

TRANSFUSION

+

PHARMACOLOGIC ADJUNCTS

Hemostatic Resuscitation



Aggressive hemorrhage control





Tourniquets

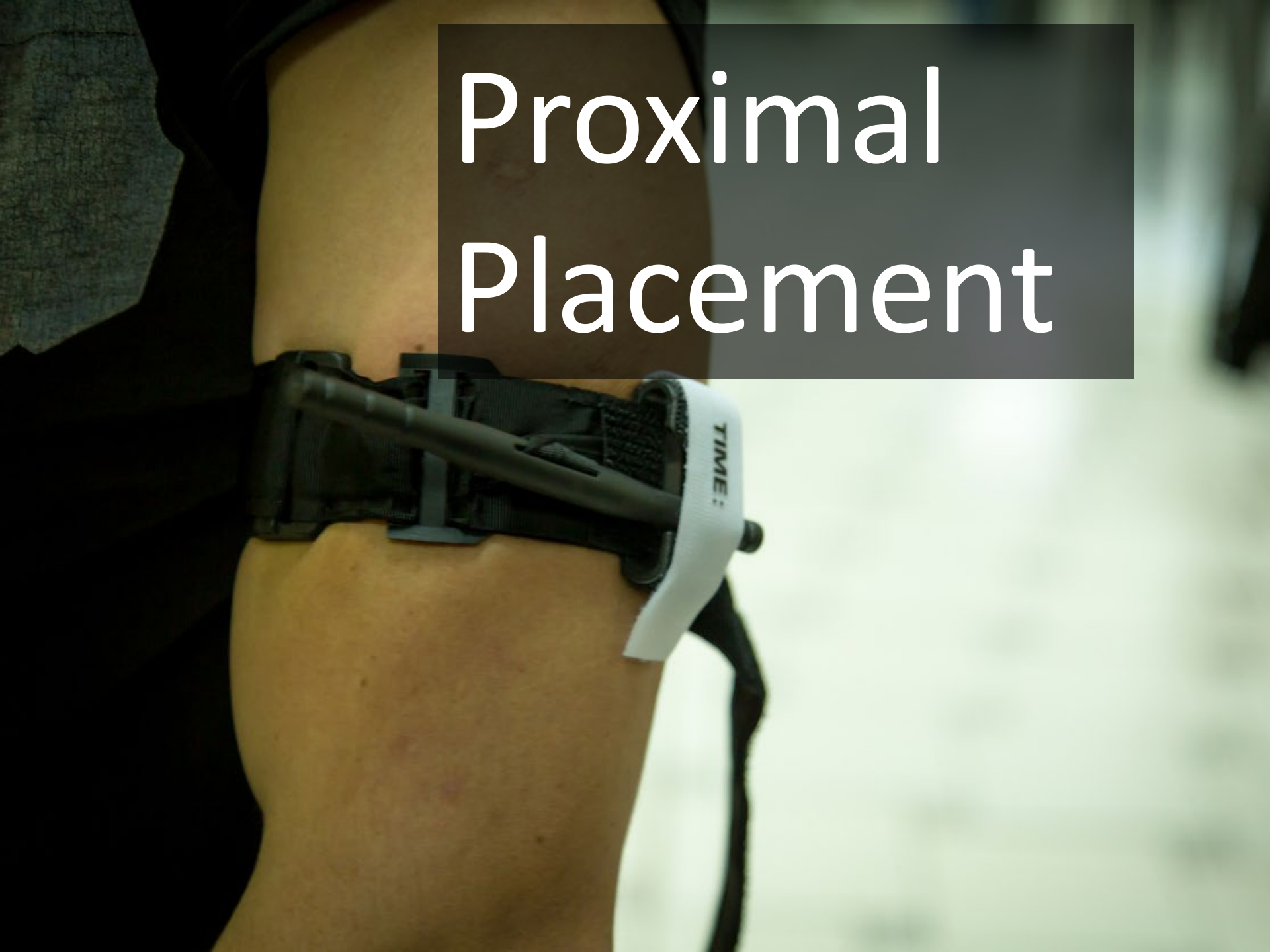
Time?



How tight?



Proximal Placement





**Wound
packing**

REF 375

FOR USE BY TRAINED EMERGENCY RESPONDERS
DIRECTIONS FOR USE

QuikClot
**COMBAT
GAUZE**

For Temporary External Use
Control Traumatic Bleeding
Vacuum Packed and Z-Folded
Hemostatic Dressing

RIP 3 IN X 4 YDS (7.5 CM X 3.7 M)

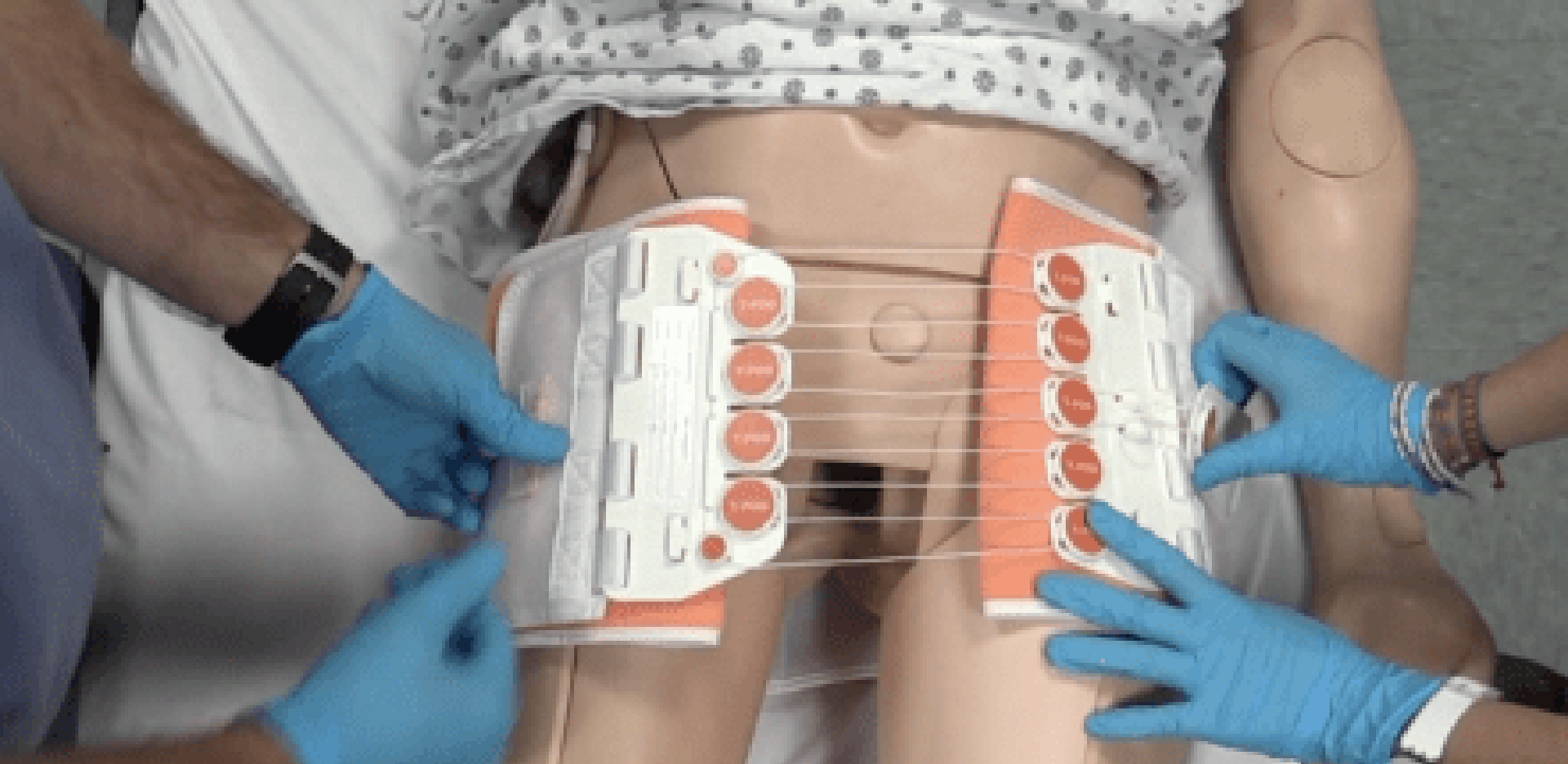
Z-MEDICA



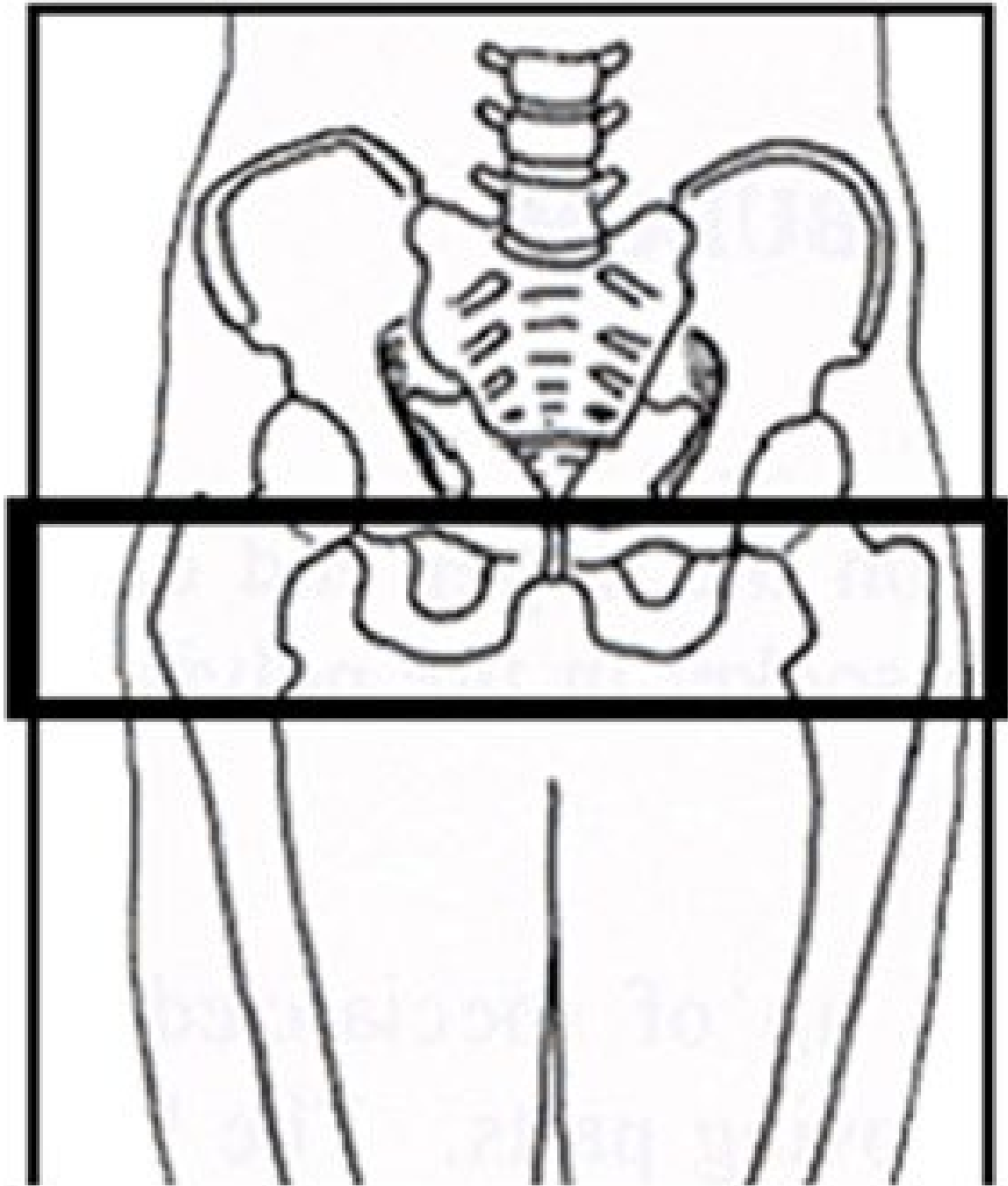
It's not such much **WHAT**
you pack it with, but
HOW you pack the
wound...



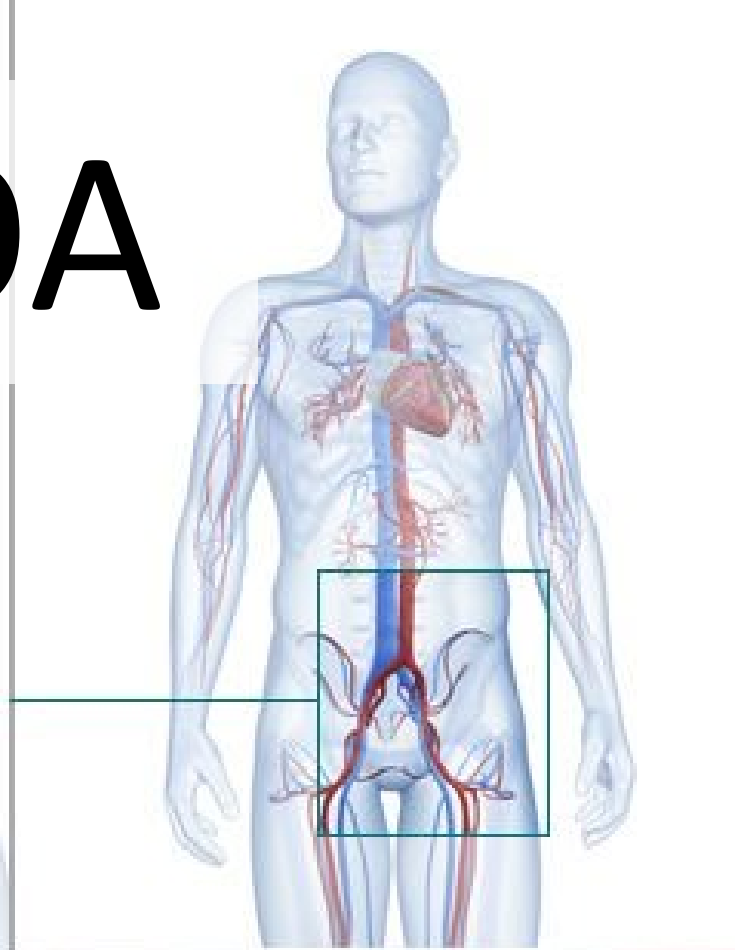
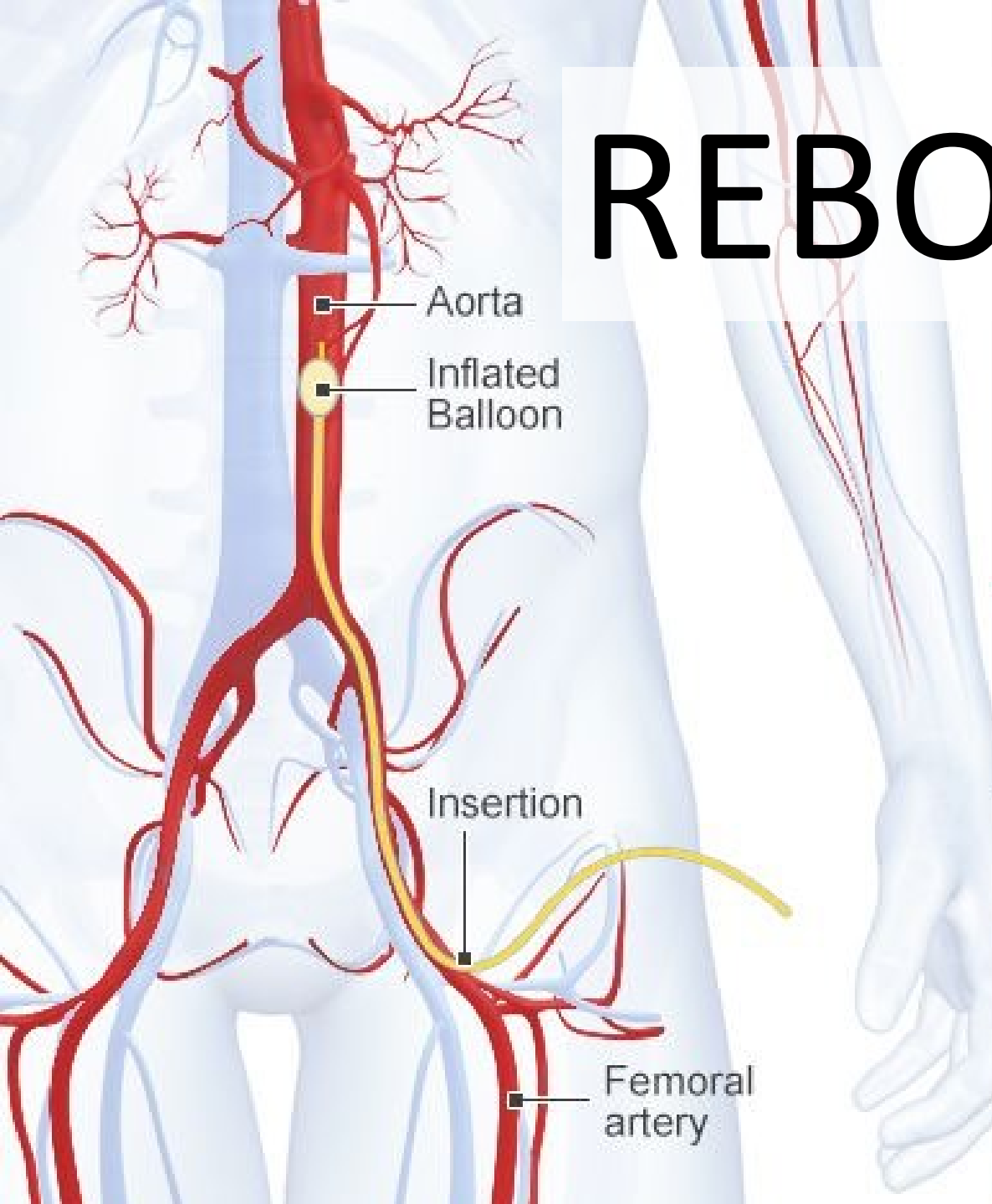




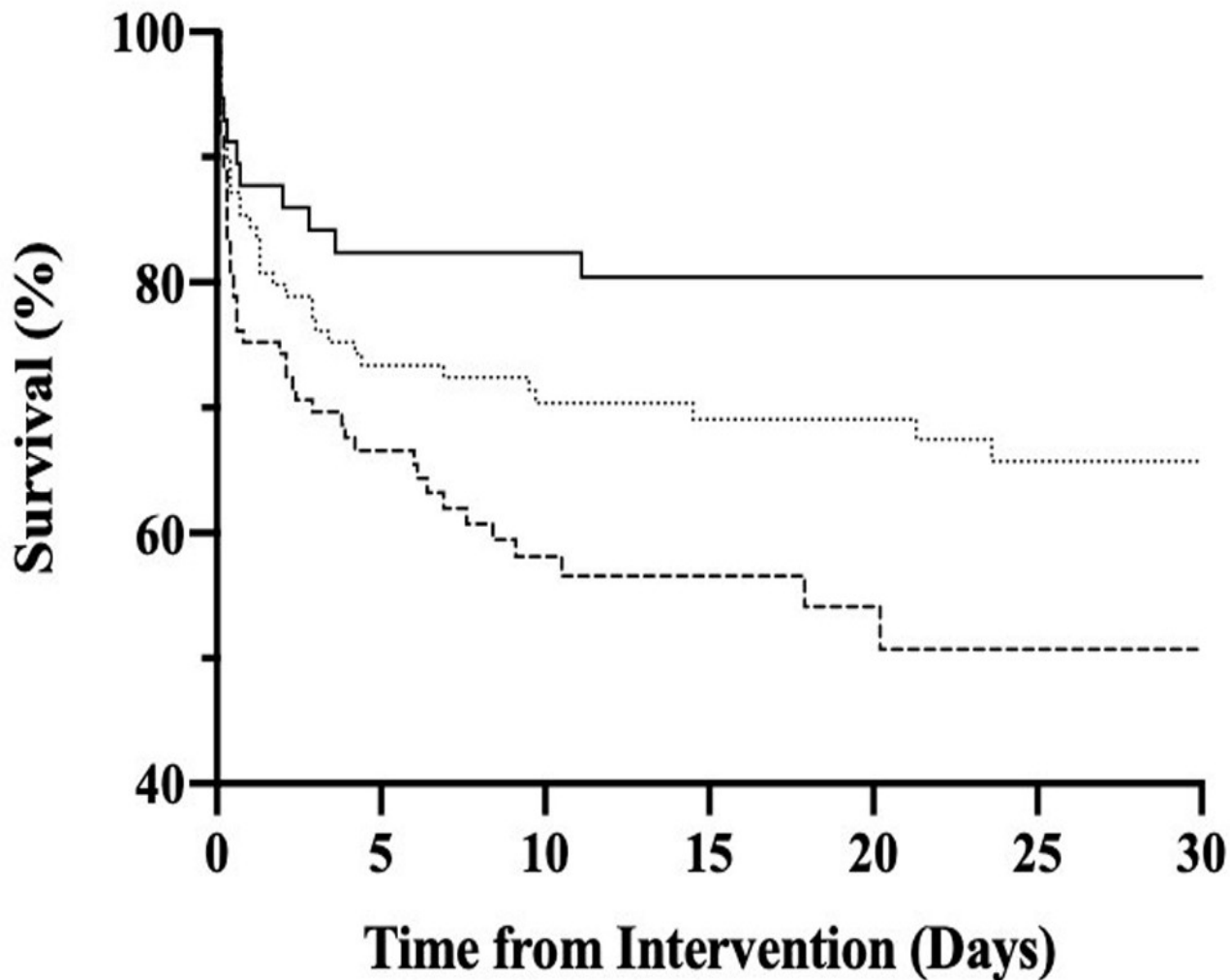
Pelvic binder application



REBOA

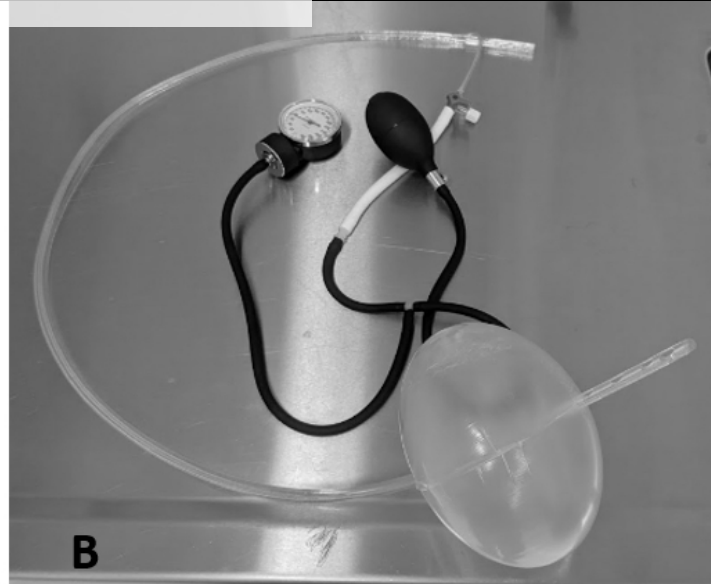
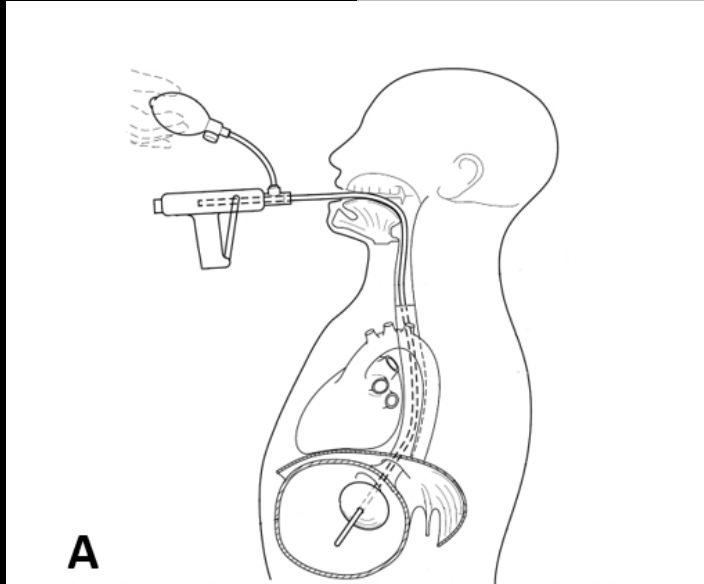


REBOA Survival

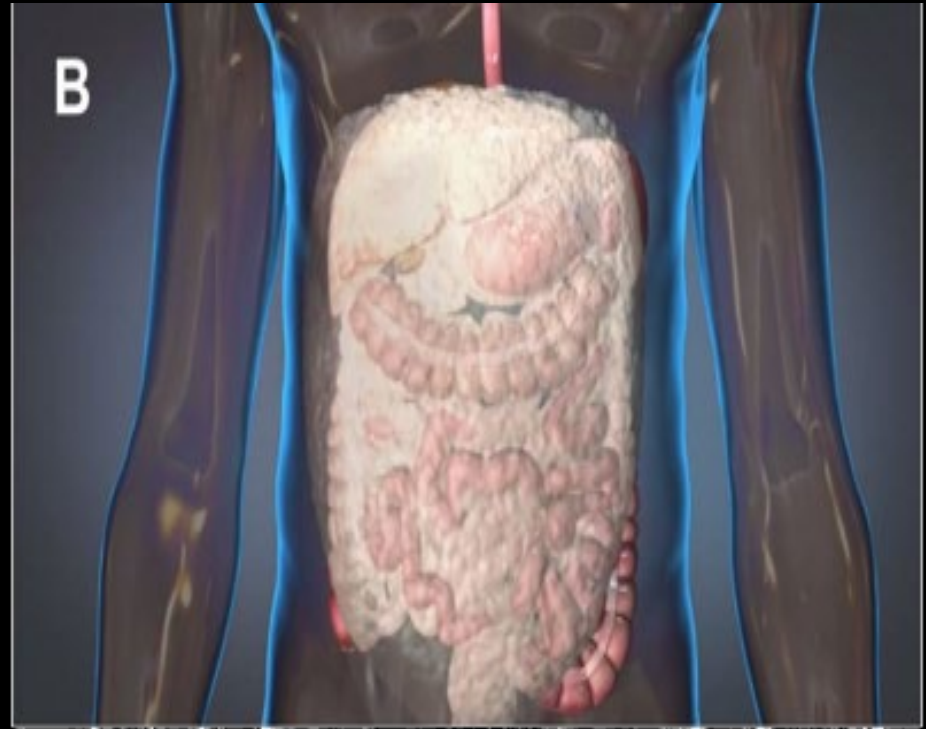
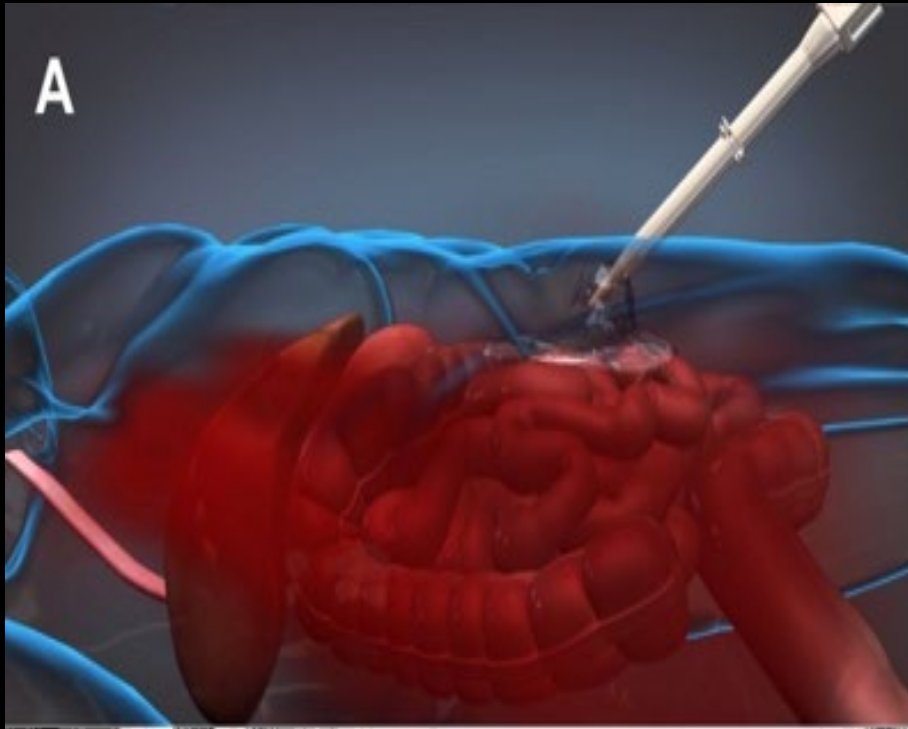




GROA



Intra-abdominal Foam



A large wooden barrel, likely used for water storage or transport, is the central focus. It is constructed from dark wood staves held together by metal hoops. A metal pipe is attached to the side of the barrel, and water is flowing out of it. The barrel is positioned in front of a waterfall, with water cascading down a rocky surface. The scene is set in a natural, outdoor environment with trees and foliage in the background.

Targeted Hemodynamics

Minimum Normotension

Civilian Evidence

Cannon et al. JAMA 1918; 618-621

Bickell *et al.* *N Engl J Med* 1994; 331: 1105-1109

Dutton RP *et al.* *J Trauma* 2002; 52(6): 1141-
1146

Systolic BP of 100 +/- (110 if
TBI, 90 if no blood)

MAP of 65 - 70

Shock Index

=

Heart Rate/SBP

Shock Index > 1.0

=

BAD

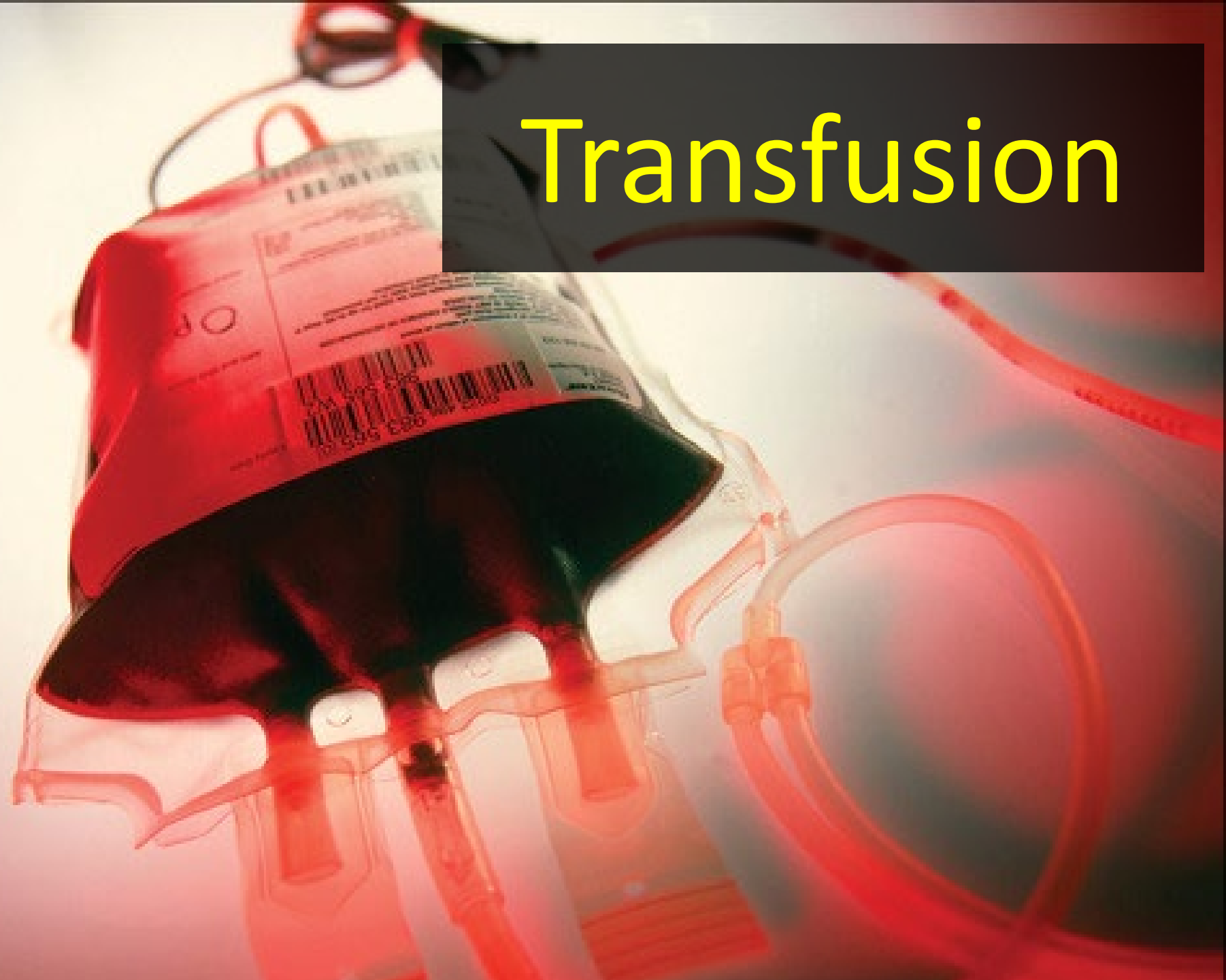
Healthy 34 y/o male GSW to the abdomen

HR: 144

BP: 104/80

Shock Index = 1.4

Transfusion

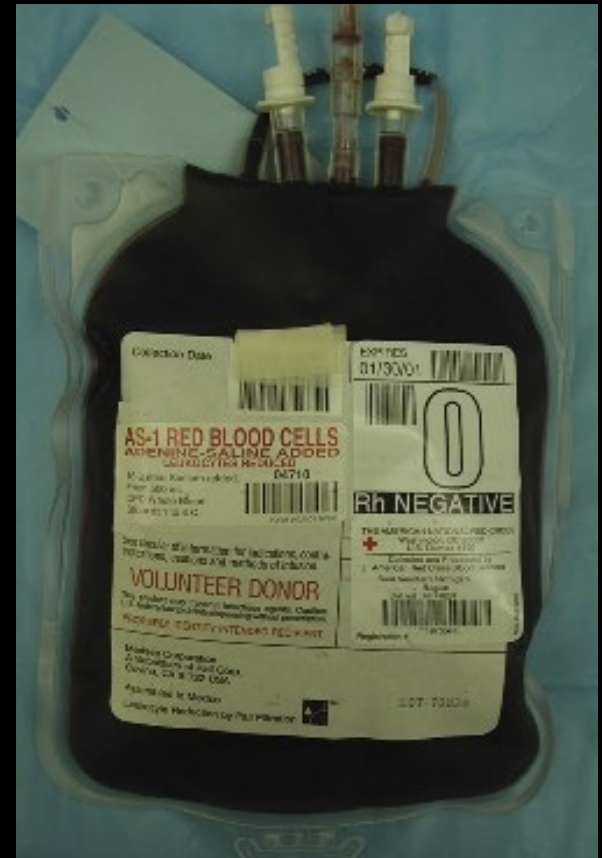


Early, empiric
administration of blood
products

Replace Blood
with Blood



Blood \neq



Red Cells

+

Plasma

+

Platelets



1 : 1 : 1

ANNALS *of* SURGERY

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No. 1

FURTHER OBSERVATIONS ON THE RESULTS OF BLOOD TRANSFUSION IN WAR SURGERY

WITH SPECIAL REFERENCE TO THE RESULTS IN PRIMARY HEMORRHAGE

By L. BRUCE ROBERTSON, M.B. (TORONTO), MAJOR C.A.M.C.

WITH A NOTE BY

COL. C. GORDON WATSON, C.M.G., F.R.C.S., A.M.S.

CONSULTING SURGEON, R. E. F.

THE TRANSFUSION OF WHOLE BLOOD: *A SUGGESTION FOR ITS MORE FREQUENT EMPLOYMENT IN WAR SURGERY.*

BY

L. BRUCE ROBERTSON, B.A., M.B. TORONTO,

CAPTAIN C.A.M.C.,

JUNIOR ASSISTANT SURGEON, HOSPITAL FOR SICK CHILDREN,
TORONTO, CANADA.

“Transfusion of blood after primary hemorrhage is a lifesaving intervention of the greatest value and enables urgent operations to be successfully performed under conditions otherwise hopeless.”

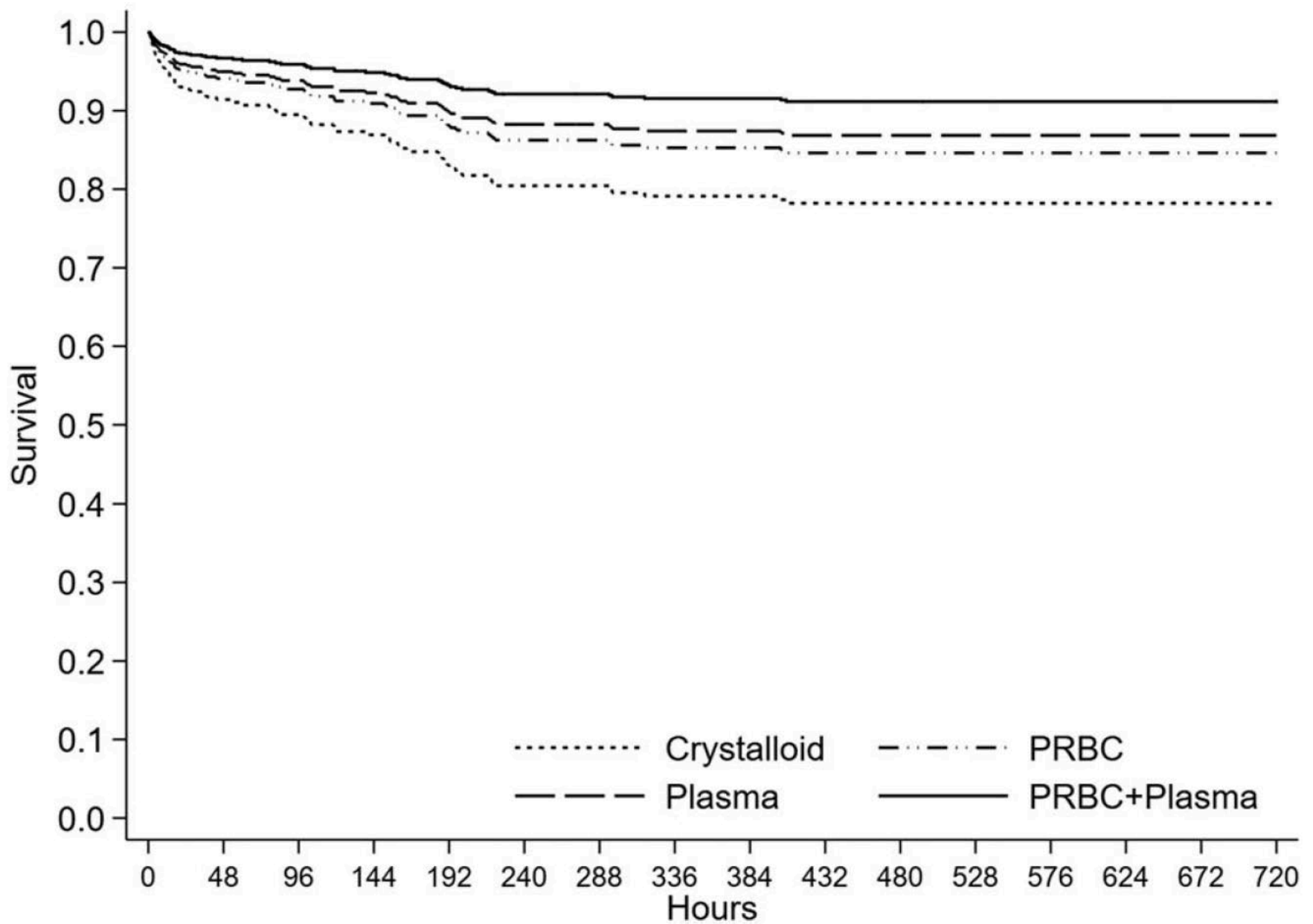
Original Investigation

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

PAMPer Trial

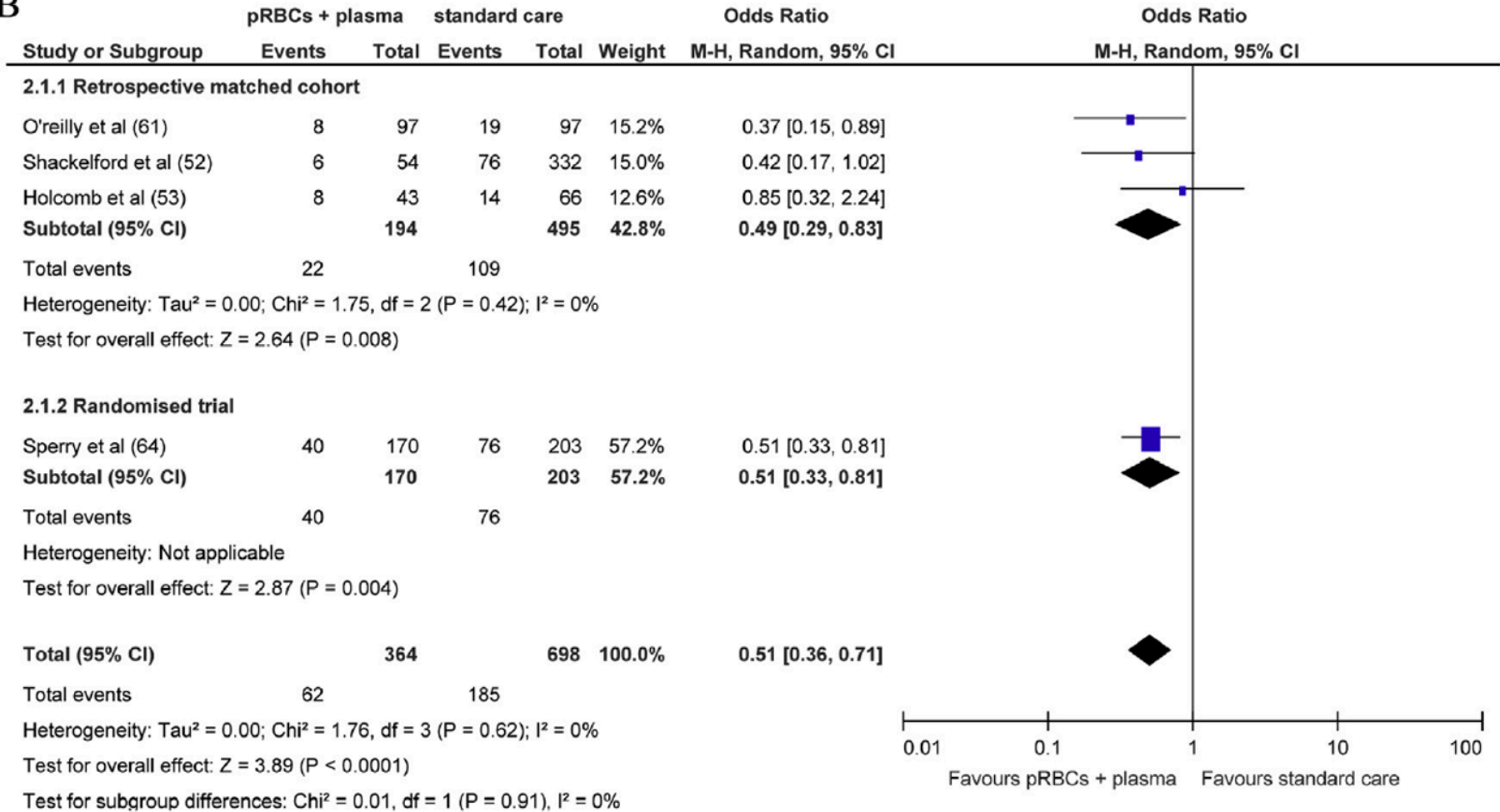




Cox proportional hazards regression adjusted survival curves based on prehospital resuscitation group. Time of randomization in the original trial. PRBC indicates packed red blood cells.

RBCs + plasma vs Standard Care

B



On the military
side...

Warm Fresh Whole Blood Is Independently Associated With Improved Survival for Patients With Combat-Related Traumatic Injuries

Philip C. Spinella, MD, Jeremy G. Perkins, MD, Kurt W. Grathwohl, MD, Alec C. Beekley, MD, and John B. Holcomb, MD

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

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



Medical supplies, including
TMR, FBT-40

Medical supplies, including
TMR, FBT-40

Know Your
Blood



On the civilian
side?



3


UPS
UNIT
#123

PELICAN
Mail™

POSITIVE

201 - 2
Pimpad -

Prehospital whole blood reduces early mortality in patients with hemorrhagic shock

Maxwell A. Braverman¹  | Alison Smith¹ | Douglas Pokorny¹ |
Benjamin Axtman¹ | Charles Patrick Shahan¹ | Lauran Barry¹ |
Hannah Corral¹ | Rachelle Babbitt Jonas¹ | Michael Shiels² |
Randall Schaefer³ | Eric Epley³ | Christopher Winckler⁴ |
Elizabeth Waltman⁵ | Brian J. Eastridge¹ | Susannah E. Nicholson¹ |
Ronald M. Stewart¹ | Donald H. Jenkins¹



Resuscitation with blood products in patients with trauma-related haemorrhagic shock receiving prehospital care (RePHILL): a multicentre, open-label, randomised, controlled, phase 3 trial



*Nicholas Crombie, Heidi A Doughty, Jonathan R B Bishop, Amisha Desai, Emily F Dixon, James M Hancox, Mike J Herbert, Caroline Leech, Simon J Lewis, Mark R Nash, David N Naumann, Gemma Slinn, Hazel Smith, Iain M Smith, Rebekah K Wale, Alastair Wilson, Natalie Ives, Gavin D Perkins, on behalf of the RePHILL collaborative group**

Adjunctive Therapies





NDC 55150-188-10

AUROMEDICS

**Tranexamic
Acid Injection**

**1,000 mg per 10 mL
(100 mg / mL)**

**For Intravenous Use
Only**

Rx only

10 mL sterile single-use vial

Each mL
injection

Usual
information

Store at
Controlled

Discard

Distrib
E. Wind

Made in



The impact of prehospital TXA on mortality among bleeding trauma patients: A systematic review and meta-analysis

Ateeq Almuwallad, MSc, Elaine Cole, PhD, Jennifer Ross, MSc, Zane Perkins, PhD, and Ross Davenport, PhD, United Kingdom

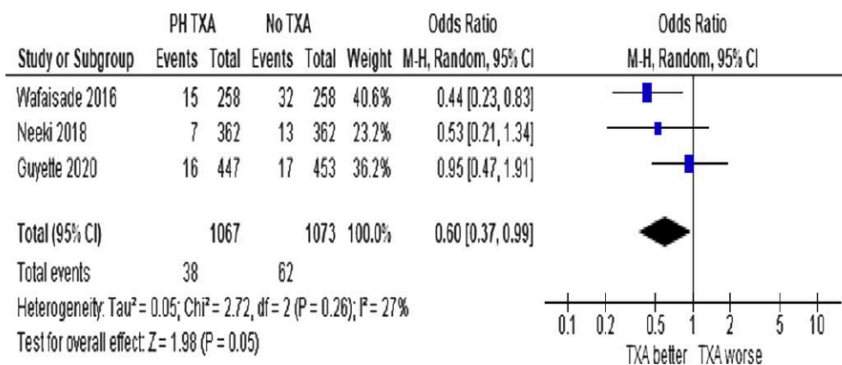


Figure 2. Forest plot of the effect (OR with 95% CIs) of prehospital TXA on 24-hour mortality.

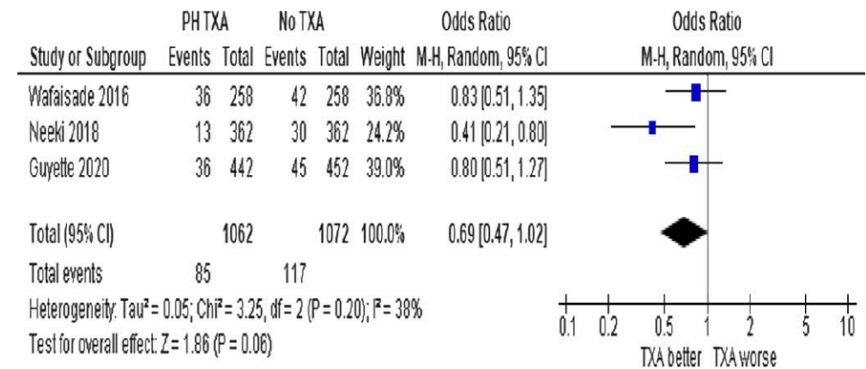
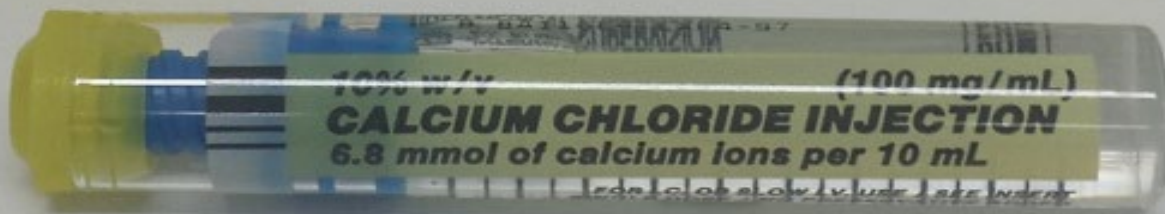
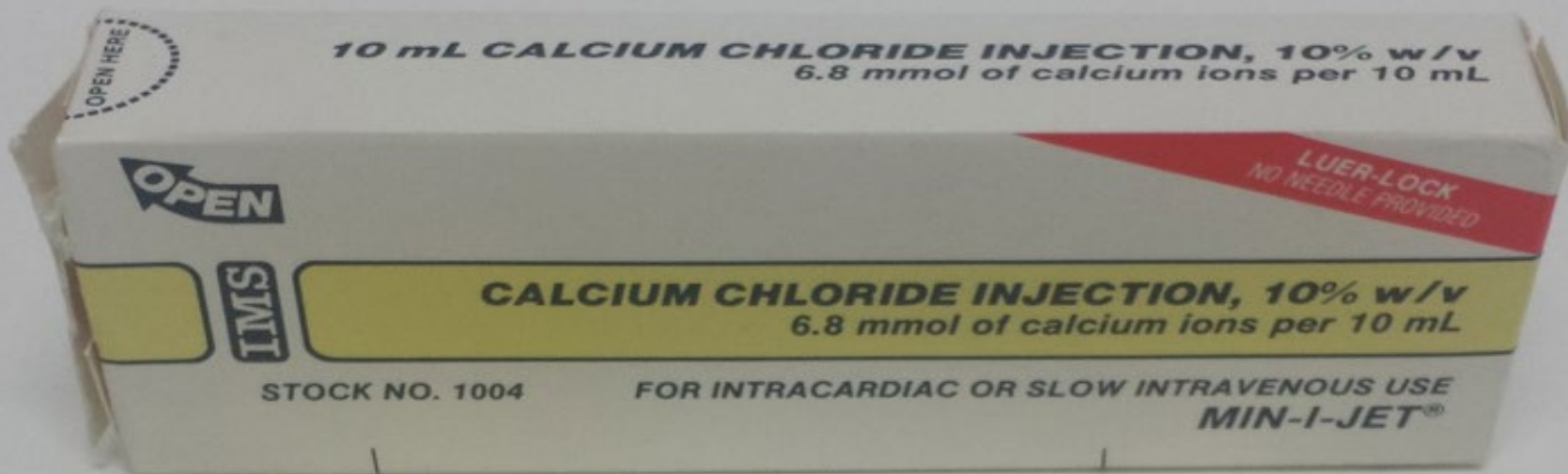


Figure 3. Forest plot of the effect (OR with 95% CIs) of prehospital TXA on 28- to 30-day mortality.



An Analysis of the Incidence of Hypocalcemia in Wartime Trauma Casualties

Mireya A. Escandon, BS
 Ashley D. Tapia, BS
 MAJ Andrew D. Fisher, MD, MPAS
 COL Stacy A. Shackelford, MD
 COL Vikhyat S. Bebarta, MD

Franklin L. Wright, MD
 Susannah E. Nicholson, MD
 MAJ Ronnie Hill, MS
 James A. Bynum, PhD
 MAJ Steven G. Schauer, DO, MS

Table 1. Demographics, injury data, and outcome data.

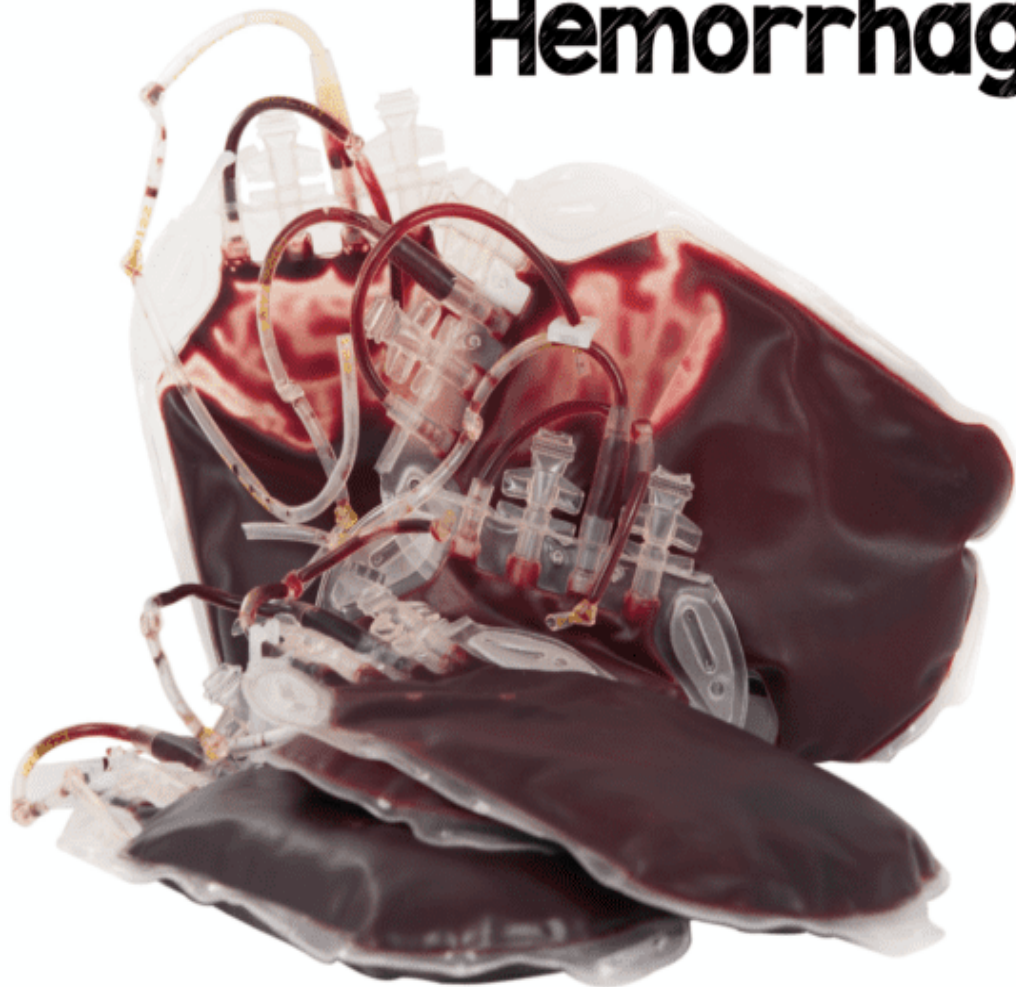
		No hypocalcemia n=70	Hypocalcemia n=72	p-value
Demographics	Age	30 (25-31)	30 (30-33)	0.166
	Male	100% (70)	100% (72)	N/A
Affiliation	US military	17% (12)	16% (12)	0.072
	NATO military	0% (0)	7% (5)	
	Non-NATO mil	52% (12)	17% (12)	
	Humanitarian	30% (21)	37% (27)	
Mechanism of injury	Explosive	51% (36)	45% (33)	0.473
	Fall	4% (3)	1% (1)	
	Firearm	38% (27)	44% (32)	
	MVC	5% (4)	5% (4)	
	Other	0% (0)	3% (2)	
Injury Score	Composite	9 (2-19)	15 (5-25)	0.010
Serious injuries by body region	Head/neck	15% (11)	23% (17)	0.257
	Face	0% (0)	1% (1)	0.322
	Thorax	11% (8)	15% (11)	0.623
	Abdomen	14% (10)	23% (17)	0.200
	Extremities	25% (18)	37% (27)	0.131
	Skin	4% (3)	1% (1)	0.362
Outcome	Alive	97% (68)	90% (65)	0.166

Table 4. Comparison of select vital signs and scores.

	No hypocalcemia	Hypocalcemia	p-value
Systolic pressure*	120.5 (115.8-125.2)	121.1 (116.6-125.6)	0.858
Diastolic pressure*	75.7 (71.7-79.7)	75.5 (72.2-78.7)	0.933
Heart rate*	100.5 (94.3-106.7)	102.5 (97.0-107.9)	0.632
Pulse oximetry#	97 (96-99)	97 (94-100)	0.395
Respiratory rate*	18.6 (17.7-19.6)	20.4 (18.9-21.9)	0.048
Temperature*	97.8 (97.4-98.2)	97.9 (97.5-98.4)	0.731
Glasgow Coma Scale#	15 (3-15)	15 (3-15)	0.639
Shock index*	1.03 (0.96-1.10)	1.07 (1.02-1.13)	0.323
Revised Trauma Score*	6.5 (6.1-7.0)	6.3 (5.9-6.7)	0.386

*Presented as means, confidence of intervals, and t-test
 #Presented as median, interquartile range, and Wilcoxon test

AVERT-Shock: Vasopressin for Acute Hemorrhage?



**REBEL
CRIT**

Arginine vasopressin, but not epinephrine, improves survival in uncontrolled hemorrhagic shock after liver trauma in pigs*

Wolfgang G. Voelckel, MD; Claus Raedler, MD; Volker Wenzel, MD; Karl H. Lindner, MD; Anette C. Krismer, MD; Christian A. Schmittinger, DVM; Holger Herff, BS; Klaus Rheinberger, MS; Alfred Königsrainer, MD

Review Article

Vasopressin in Hemorrhagic Shock: A Systematic Review and Meta-Analysis of Randomized Animal Trials

**Andrea Pasquale Cossu,¹ Paolo Mura,¹ Lorenzo Matteo De Giudici,¹
Daniela Puddu,¹ Laura Pasin,² Maurizio Evangelista,³ Theodoros Xanthos,⁴
Mario Musu,¹ and Gabriele Finco¹**





Paradigm shift for
initial resuscitation

Critical injury ***DOES NOT***
respect geography...



PREHOSPITAL CARE



PRESURGICAL CARE

Minimum Presurgical Goals

- **Achieve hemostasis** within scope of practice
- Provide definitive airway (adequate ventilation and oxygenation)
- **Maintain normothermic** patient (>96°F or 36°C)
- Obtain IV/IO access
- **Provide fluid resuscitation** as appropriate (with FWB or products)
- **Maintain minimum normotension** until definitive surgical care
- Administer prophylactic antibiotic therapy
- Record/communicate trends in physiologic parameters

Damage Control Resuscitation



Summary

Hemostatic Resuscitation

Targeted Hemodynamics

Transfusion

Pharmacologic Adjuncts

QUESTIONS?