Hemostasis:
Stop that Bleed!

A Lecture on Damage Control Resuscitation (DCR)

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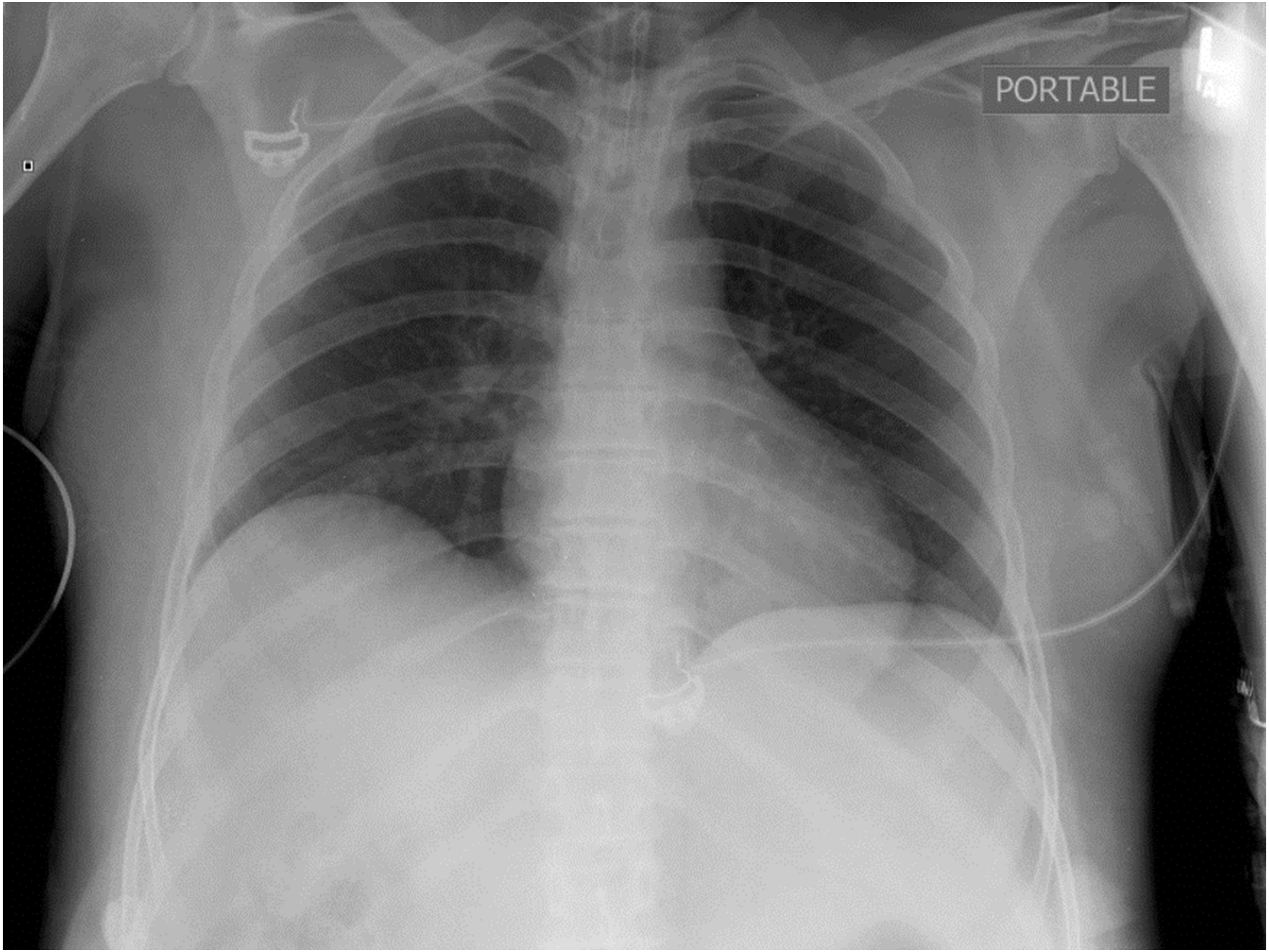
Free!

Trauma Talk

Minimal Evidence
Strong Opinions

Case

33 y/o female
SUV vs. Left Hip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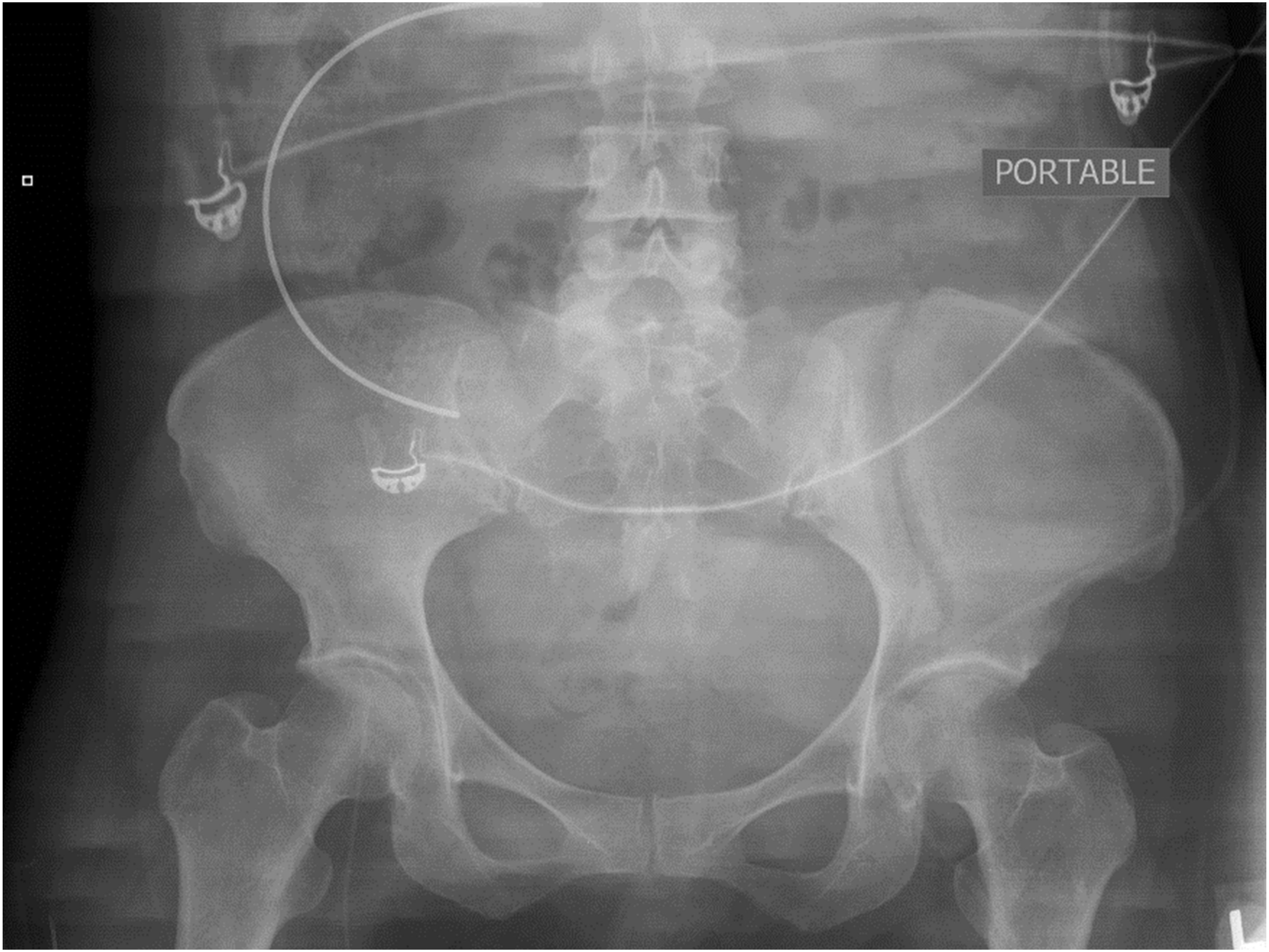
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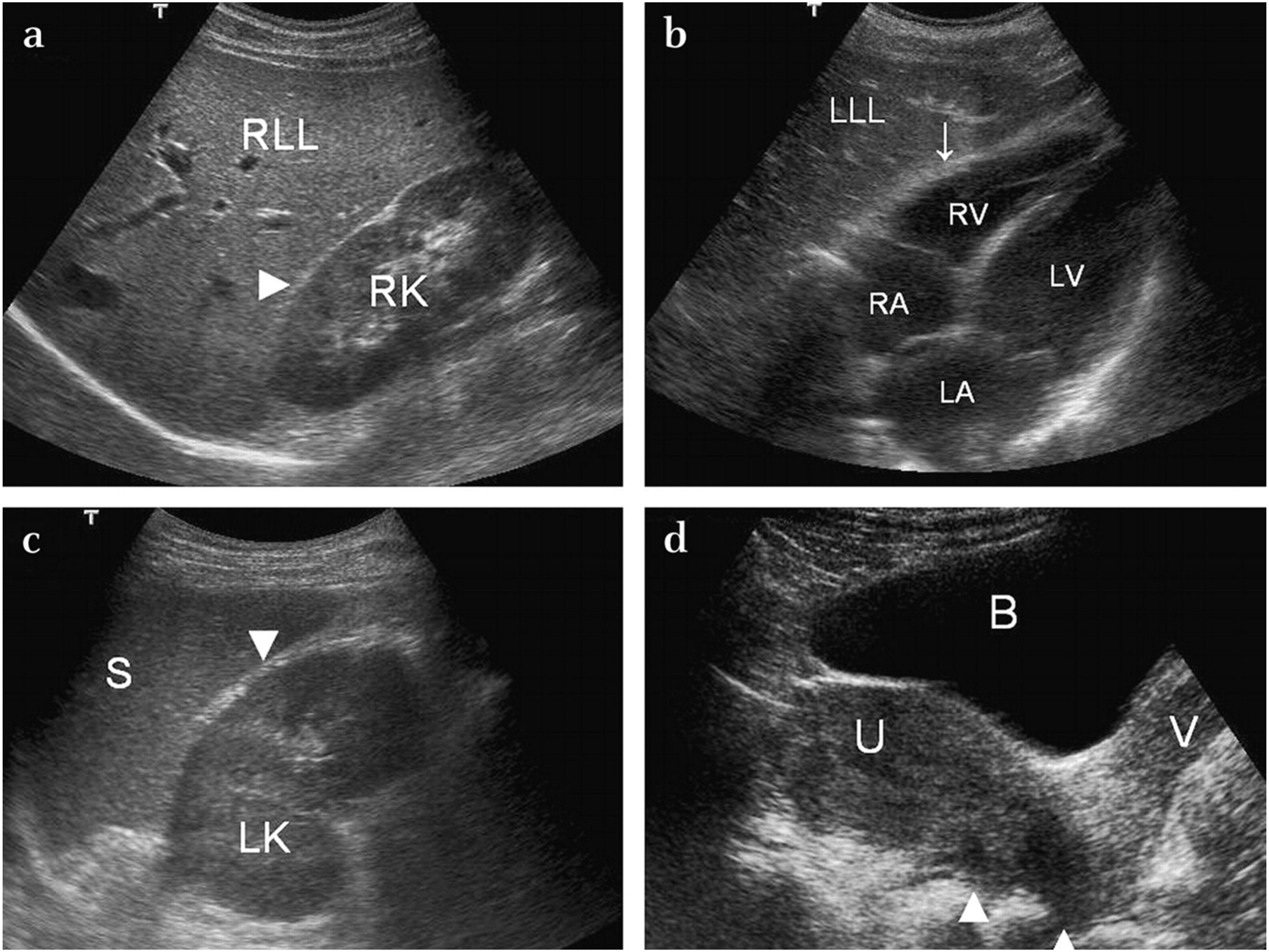

a
RLL
RK
b
LLL
RV
LV
RA
LA
c
S
LK
d
B
U
V

DPL

Angio will be in…

The Old Days

Damage Control Resuscitation

(DCR)

Minimize Iatrogenic Injury from Resuscitation

Control Internal/External Bleeding as rapidly and safely as possible

Promote Hemostasis

Restore Tissue Perfusion

3 Facets of DCR

Massive Transfusion Protocols & Hemostatic Resuscitation

Minimal Normotension (i.e. Permissive Hypotension)

External Bleeding Control

Objective:

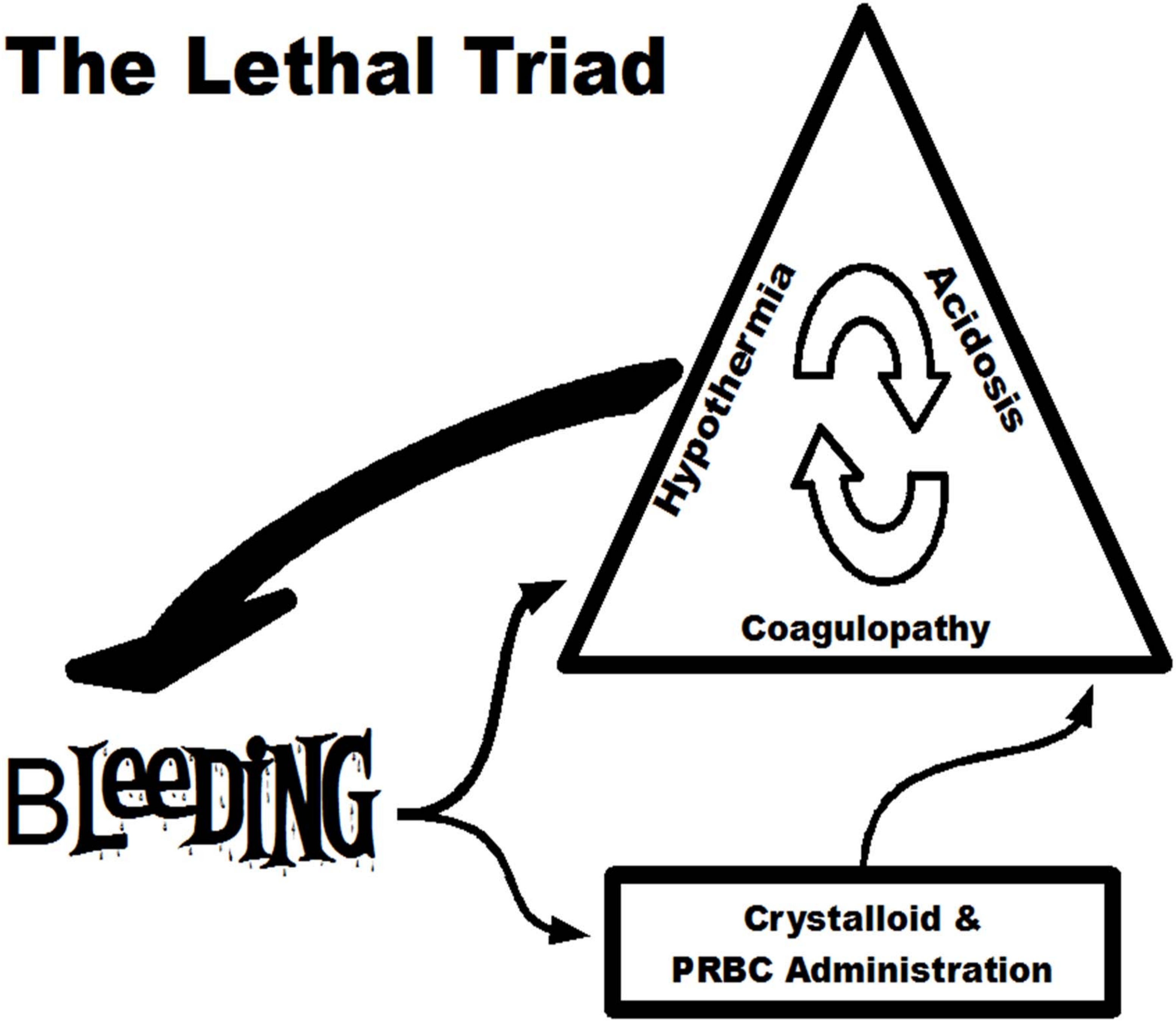
To offer new concepts that will help you manage the crashing trauma patient

The Lethal Triad

The Lethal Triad

ENEMY

The Lethal Triad



Acute Coagulopathy of Trauma

ACoT

Consumption

Consumption

Acidosis/
Hypothermia

Consumption

Acidosis/

Hypothermia

Dilution

Consumption
Acidosis/
Hypothermia
Dilution
Tissue Factors

Consumption

Acidosis/

Hypothermia

Dilution

Tissue Factors

Hyperfibinolysis

Gross Simplification

Tissue Injury
+
Hypoperfusion

=

Coagulation Badness

What do we do about it?

Patient Tailored Approach

Patient Tailored Approach

Crappy


Driving Backwards


Military Conflict leads to
Trauma Medicine Advances

Hemostatic Resuscitation

Give no fluid that can't either carry oxygen or promote clotting

Massive Transfusion Protocols

Benefit at 1 Blood Volume

(Or 8-10 units in 24 hours)

Predicting Who Will Need It

ABC Score

- Penetrating Mechanism
- Systolic Blood Pressure ≤ 90
- Heart Rate ≥ 120 bpm
- Positive FAST abdominal views

TASH Score

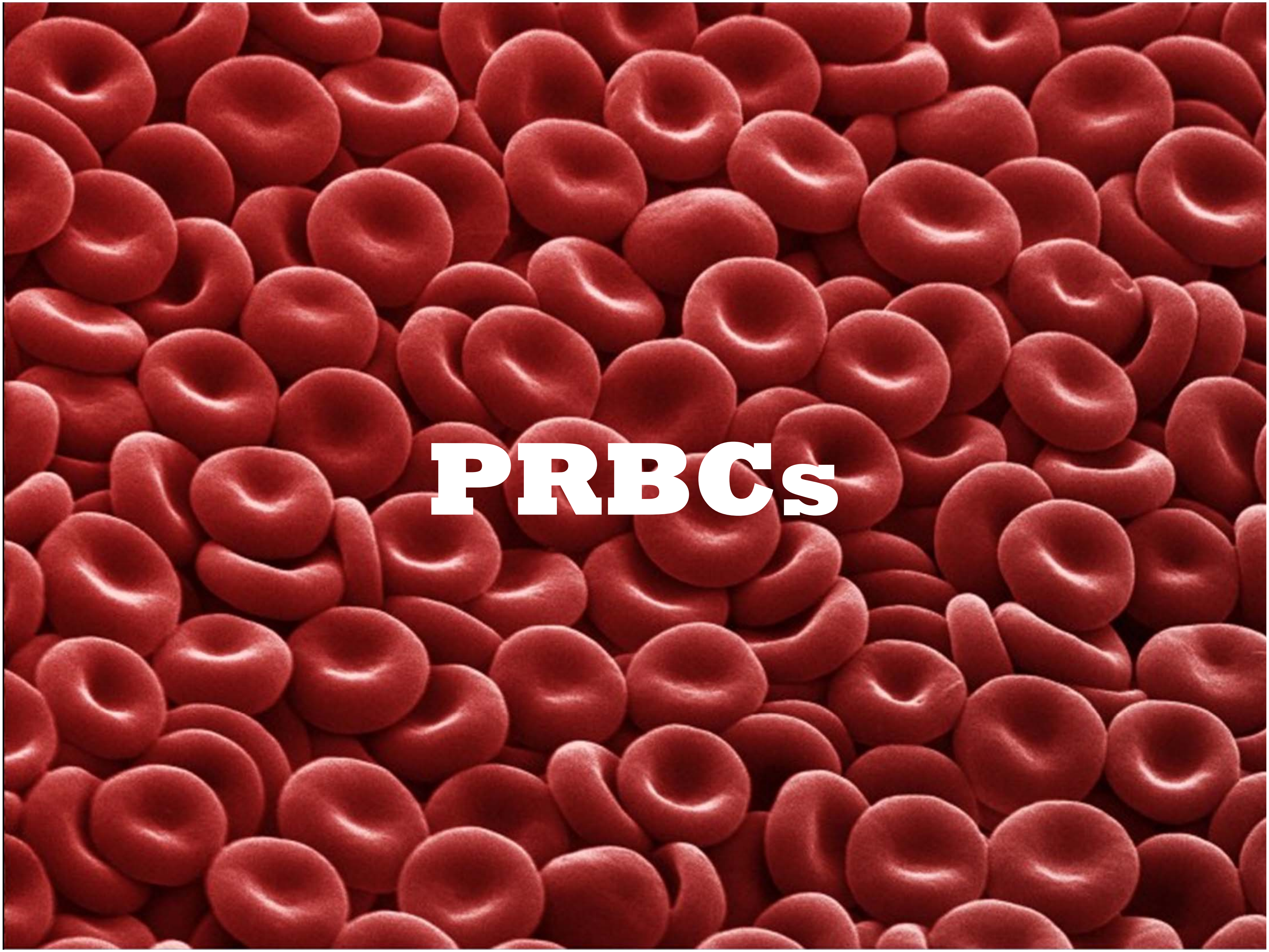
- Systolic blood pressure <100 mm Hg
- Heart rate >120
- Hemoglobin <7 g/dL
- Positive FAST Exam with hemodynamic instability
- Complex long bone and/or pelvic fracture
- Base excess < - 10 mmol/L
- INR > 1.5 during resuscitation period

Looks Like Poo
Doesn't Respond

Whole Blood


Walking
Blood Bank

1:1:1

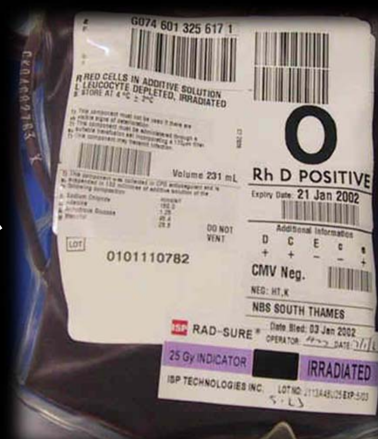

PRBCs

Plasma

COLLECTION DATE
06-02-09
2815950
DONOR NO.
EXPIRY DATE
06/02/2010
Fresh Frozen Plasma
from 450 ml whole blood
a18200a
Store at < -30C
B
Rh D POSITIVE
Collected and Processed by
The Hong Kong Red Cross BTS
15, King's Park Rise, Yaumatei, Kowloon.
CAUTION: Although this unit has been tested non-reactive for anti-HIV1+2, anti-HCV, anti-HTLVI, HBsAg and syphilis, risk of infection still exists.
Registration # 1234567
LOT
Manufactured by
JMS SINGAPORE PTE LTD
440 Ang Mo Kio Industrial Park 1 Singapore 569620

FFP + PRBC = Resus Fluid


Fresh Frozen Plasma
B
Rh D POSITIVE


G074 601 325 617 1
RED CELLS IN ADDITIVE SOLUTION
LEUCOCYTE DEPLETED, IRRADIATED
O
Rh D POSITIVE
Expiry Date: 21 Jan 2002
CMV Neg.
NBS SOUTH THAMES
0101110782
RAD-SURE
25 Gy INDICATOR
IRRADIATED
ISP TECHNOLOGIES INC.


Platelets

The Evidence

Table 1 Blood component therapy in trauma patients requiring massive transfusion

Author, country, date	Patient group	Study type	Outcomes	Key results	Study weaknesses
Borgman *et al*, 2007, USA/Iraq	246 combat casualties admitted to combat hospital in Baghdad, Iraq, November 2003 to September 2005 who were given ≥10 units RBCs (PRBCs or fresh whole blood) in first 24 h. Three groups analysed according to low (0:12–1:5), intermediate (1:3.0–1:2.3) and high ratio (1:1.7–1:1.2) of units of FPP:PRBCs. Overall mortality 28%.	Registry review	Survival of high vs intermediate vs low ratio of FFP:PRBC. Median time to death for high vs intermediate vs low ratio. rFVIIa used in 81 patients.	131/162 (81%) vs 35/53 (66%) vs 14/31(45%) 38 h vs 4 h vs 2 h. 61/81 (75%) of patients survived.	Retrospective. Fresh whole blood was viewed as 1:1:1 PRBCs:FFP:PLT. Unlikely to reflect community setting with high degree of penetrating trauma and highly focused prehospital care. rFVIIa administered to 32% of patients. Higher incidence of thoracic trauma in low ratio group. This group died early. Haemoglobin lower in low ratio group. Selected patients received rFVIIa Those who rapidly exsanguinate have little time for damage control therapy.
Maegele *et al*, 2008, Germany	713 ISS >16 received >10 units PRBC. Grouped according to FFP:PRBC ratios. Overall mortality 42%.	Registry review.	Overall survival according to FFP:PRBC ratio High (>1:1) vs low (<1:2).	153/229 (67%) vs 262/484 (54%).	Open to selection bias.
Duchesne *et al*, 2008, USA	135 massively transfused trauma patients receiving >10 units PRBCs. Patients not receiving FFP were excluded. 55% mortality.	Retrospective chart review.	Survival FFP:PRBC ratio 1:1 vs 1:4.	52/71 (73%) vs 8/64 (12.5%).	Retrospective. Slightly different criteria for massive transfusion (>10 units).
Kashuk *et al*, 2008, USA	133 trauma patients receiving > 10 units PRBC in first 6 h. 56% mortality.	Retrospective review of prospectively entered data over 5-year period.	Survival probability according to ratio of FFP:PRBCs 1:1 vs 1:2–1:3 vs ≥1:5.	Approximately 43% vs 72% vs 9%.	Subject to bias of retrospective study. Probabilities generated based on small numbers, raw survival data not provided.
Gunter *et al*, 2008, USA	259 trauma patients. Pre-Trauma Exsanguination Protocol (TEP) vs post TEP protocol. Overall mortality 56%.	Retrospective cohort study.	30-day survival FFP:PRBC ≥1:1.5 vs <1:1.5. 30-day survival PLT:PRBC ≥1:1.5 vs 1:<1.4. 30-day survival for pre-TEP vs post-TEP groups.	38/64 (59%) vs 74/195 (38%). 39/63 (62%) vs 76/196 (39%). 37/140 (53%) vs 61/119 (61%).	Data for post-TEP group gathered prospectively while pre-TEP group data all retrospective. TEP protocol initiated by trauma surgeon upon arrival. Selection bias (discretionary decision-making unavoidable). More penetrating injury in pre-protocol group (61%) vs 48% in post-protocol group.
Holcomb *et al*, 2008, USA	466 trauma patients who received ≥10 units of PRBCs in first 24 h. 65% blunt injury. Patients divided into groups according to FFP:PRBCs and subgroups according to FFP:platelets:PRBCs. Overall mortality 41%.	Multicentre retrospective.	30-day survival by ratio FFP:PRBC; high (≥1:2) vs low (<1:2). 30-day survival by ratio platelets:PRBC; high (≥1:2) vs low (<1:2). 30-day survival platelets and FFP: PRBC high vs low.	165/252 (66%) vs 112/214 (52%). 166/234 (71%) vs 111/232 (48%). 110/151 (73%) vs 56/131 (43%).	Retrospective.
Sperry *et al*, 2008, USA	415 trauma patients transfused ≥8 units in first 12 h divided into high (≥1:1.5) and low (<1:1.5) FFP:PRBCs ratios. Identified from collaborative data base. Median transfusion of 14 units PRBCs. Overall mortality 33.5%.	Multicentre prospective data entry retrospective review.	Survival according to ratio of FFP:PRBC ≥1:1.5 vs <1:1.5. Multiorgan failure high vs low ratio. Infection rate high vs low ratio. ARDS 24 h PRBC transfusion requirement.	72/102 (71%) vs 203/313 (65%). 64% vs 54%. 58% vs 43%. 47% vs 24%. 16 (9) vs 22 (17).	Open to selection bias; severe trauma group received high ratio component therapy. rFVIIa used variably. Data collated from study with different primary objective. Higher cryoprecipitate administration in high ratio group.
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Perkins *et al*, USA Iraq, 2009	456 trauma patients in military hospital in Baghdad receiving ≥10 units PRBCs and variable units of apheresis platelets in first 24 h.	Retrospective review of records of patients admitted to combat hospital January 2004–December 2006.	Survival to 24 h days aPLT: PRBC ratio (≥1:8) vs n = 96 vs medium (1:16–<1:8) n = 151 vs low ratio (<1:16) n = 209. Survival to 30 days high vs medium vs low ratios.	91/96 (95%) vs 131/151 (87%) vs 134/209 (64%). 45/60 (75%) vs 51/85 (60%) vs 64/150 (43%).	Military combat setting (skewed to young male penetrating trauma) may not apply to civilians. More use of adjuvant therapy (FFP, cryoprecipitate and rFVIIa) in medium to high ratio group. Large numbers lost 30-day survival follow-up.
Dente *et al*, USA, 2009	Trauma patients received to urban level 1 trauma hospital for 12 months from February 2007 receiving ≥10 units PRBCs.	Prospective trauma cases with massive transfusion protocol activation n = 73 vs historical controls n = 84.	30-day survival pre vs post MTP. Ratio FFP:PRBC pre MTP vs post MTP. First 6 h use of components pre MTP vs post MTP. Crystalloid use pre vs post MTP. 24 h survival for post MTP "successes" FFP:PRBC ratio <1:2 vs post MTP violations (>1:2–2.9 and >1:3).	64% vs 83%. 1:3 vs 1:1.9. 5.5 vs 13.7 units FFP. 14.1 vs 9.2 units PLT. 9.4 l vs 6.9 l. 43/50 (66%%) vs 3/16(81%) vs 4/7 (43%).	Limitations of historical cohort. Possible that early aggressive use of components may be more important than ratio.
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Emerg Med J 2010;1:53

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Early Use of Products Saves Products

Survival Bias

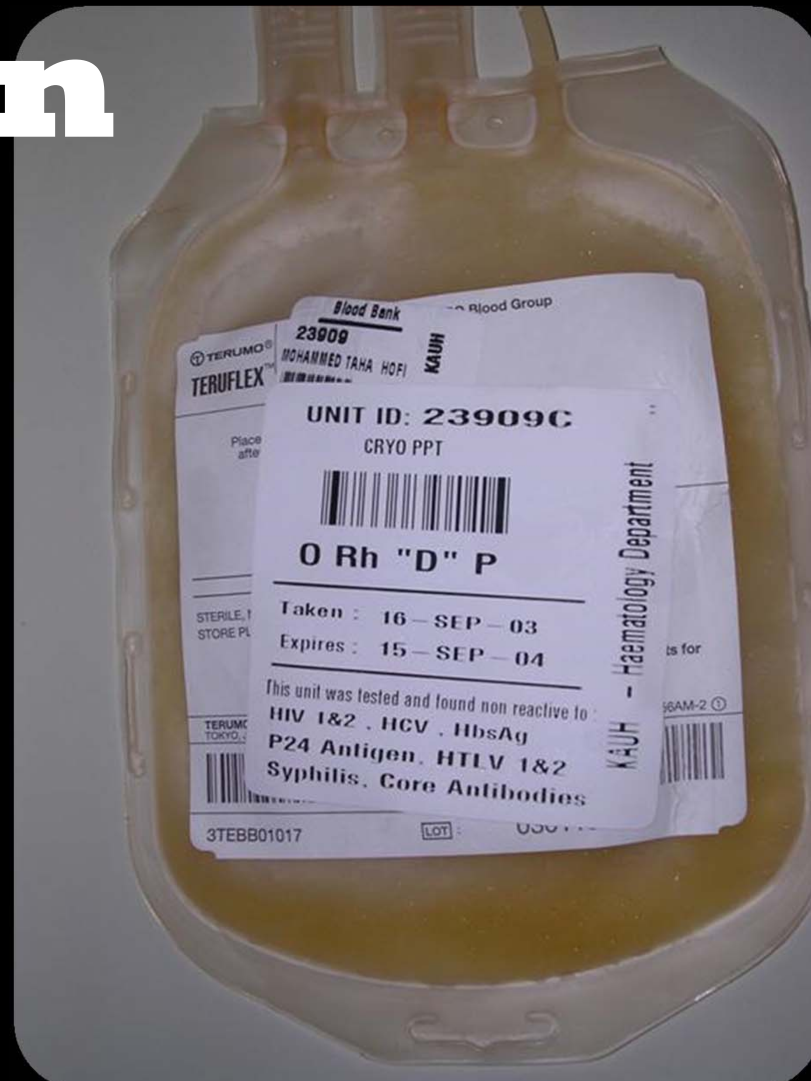
(J Trauma 2009; 66:358)

Remove the Military

(Acad Emerg Med 2009; 16:371)

Other Parts of Hemostatic Resuscitation

Fibrinogen



Blood Bank
23909
MOHAMMED TAHA HOFI
KAUH
Blood Group
TERUMO
TERUFLEX
UNIT ID: 23909C
CRYO PPT
O Rh "D" P
Taken : 16 — SEP — 03
Expires : 15 — SEP — 04
This unit was tested and found non reactive to :
HIV 1&2 . HCV . HbsAg
P24 Antigen. HTLV 1&2
Syphilis. Core Antibodies
KAUH – Haematology Department
3TEBB01017
LOT

Calcium


NovoSeven®
Coagulation
Factor VIIa
(Recombinant)
1.2 mg
2.4 mg
4.8 mg
For i.v. administration only
Single dose vial
Administer within 3 hours of reconstitution
Contains no preservative
Rx only
For intravenous administration
Reconstitute with 8.5 mL Sterile Water for Injection, USP

Factor VIIa

Don’t worry about it… not an ED Drug

Current Evidence Based Guidelines for Factor VIIa Use in Trauma: The Good, the Bad, and the Ugly

JUAN C. DUCHESNE, M.D.,* KAVITHA A. MATHEW, M.D.,* ALAN B. MARR, M.D.,† MICHAEL R. PINSKY, M.S.,*
JAMES M. BARBEAU, M.D., J.D.,‡ NORMAN E. MCSWAIN, M.D.*

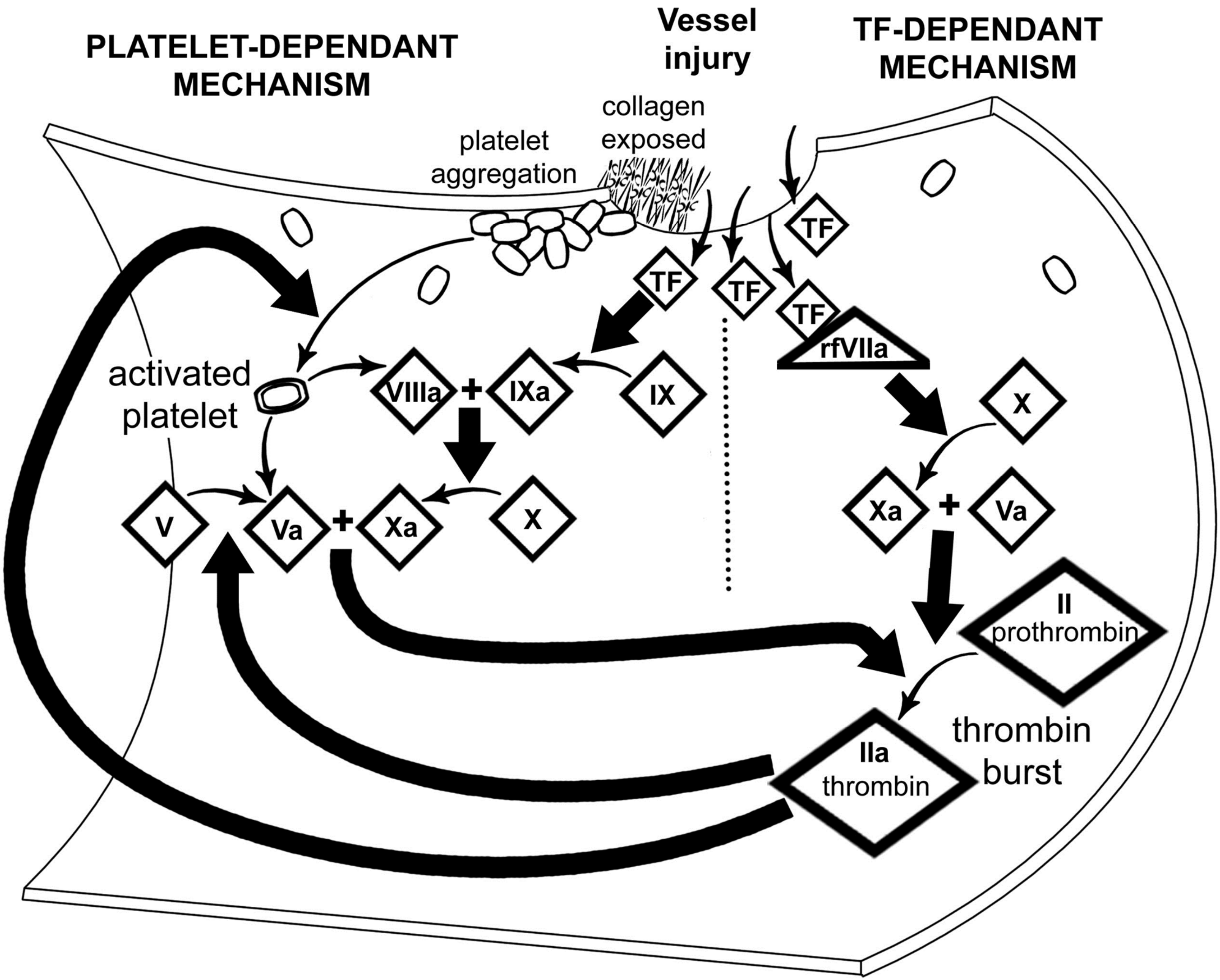
*From the *Departments of Surgery and Anesthesiology, Tulane School of Medicine, New Orleans, Louisiana and the Departments of †Surgery, ‡Pathology, and Blood Bank, Louisiana State University School of Medicine, New Orleans, Louisiana*

Am Surg. 2008 Dec;74(12):1159-65

Table 1. Evidence Based Table

	Author	Study Outcome
Class I	Boffard et al. 2005[18]	Three doses of rFVIIa (200, 100, 100 μg/kg) with first dose given after transfusion of eight RBC units and additional doses at 1 and 3 hours later resulted in: 1) a statistically significant reduction in RBC units used by 2.6 in blunt trauma 2) significant reduction in the need for massive transfusion in blunt trauma 3) similar although statistically insignificant trends were also noted in penetrating trauma 4) no difference in adverse events among treatment groups 5) trend towards decreased mortality
Class II	Dutton et al. 2004[13]	Use of FVIIa should be considered for any patient with coagulopathic hemorrhage in which surgically assessable bleeding has been controlled
	Harrison et al. 2005[19]	Trauma patients who received rFVIIa (40 μg/kg repeated once if needed) resulted in fewer packed RBC transfusions as compared with controls (18.3 ± 7.5 vs 22.0 ± 9.7; P = 0.036) Fewer platelet transfusions (1.4 ± 1.2 vs 2.3 ± 2.1; P = 0.01) Less cryoprecipitate (0.59 ± 0.54 vs 1.5 ± 1.8; P = 0.0006) Equivalent mortality was noted
	Spinella et al. 2008[23]	Retrospective review in patients with severe combat-related trauma (ISS > 15) and massive transfusion (pRBC > 10 U/24 hrs) comparing mortality in those that received rFVIIa with those that did not. One hundred and twenty-four cases were reviewed: 49 patients received rFVIIa and 75 did not. Statistically significant reductions in 24 hour mortality (14% vs 35%, P = 0.01), 30 day mortality (31% vs 51%, P = 0.03) were noted in rFVIIa group compared with nonrFVIIa patients. There similar incidence of severe thrombotic events in both groups
	Stein et al. 2008[24]	Retrospective review of 63 coagulopathic (INR ≥ 1.4) TBI patients and the time to intervention in patients treated with rFVIIa *versus* conventional therapy with FFP. Patients treated with rFVIIa were shown to have statistically significant reduction in: median time to neurosurgical intervention (144 min vs 446 min, P = 0.0003), mean INR, and mean number of units of FFP transfused compared with conventionally treated patients. There were no significant differences in discharge GCS, mortality, or incidence of thromboembolic complications between the two groups
Class III	Martinowitz et al. 2002[19]	Reported 19 critically ill, multitransfused patients with trauma (10 blunt and nine penetrating) treated with rFVIIa. 1) Total dose to control bleeding was 195 ± 112.7 μg/kg. 2) Showed a significant decrease in transfusion requirements was observed (30 ± 18.3 units used within 5.6 ± 3.4 hours of admission to 2.8 ± 2.5 units within the following 24 hours, P < 0.05) 3) Concluded rFVIIa to be a promising adjunctive hemostatic treatment for trauma patients suffering from massive bleeding.
	Rhys Thomas et al. 2007[20]	Retrospective review of patients treated with rFVIIa for thromboembolic (TE) complications. Of 285 patients treated with rFVIIa, 27 (9.4%) patients were noted to have TE complications after rFVIIa administration. No association was found between sex, age, dose, or type of trauma between the TE and nonTE groups. Based on expert panel opinion, 9/27 TE events (3.1% of entire cohort) were thought to be highly related to rFVIIa dose.
	Martinowitz et al. 2001[11]	Seven massively bleeding multitransfused patients were treated with rFVIIa (median dose of 120 μg/kg) after failure of conventional therapy. 1) Resulted in a cessation of diffuse bleeding with a significant decrease of blood requirements to two units (P < 0.05), a shortening of PT and aPTT from a median of 24 seconds to 10.1 seconds (P < 0.005) and 79 seconds to 41 seconds, respectively. 2) An increase of FVII level from 0.7 IU/mL to 23.7 IU/mL (P < 0.05) was also noted
	Vick and Islam 2008[25]	Review of eight pediatric blunt abdominal trauma cases that were managed nonoperatively for persistent bleeding with rFVIIa. Patients received 75 to 90 mcg/kg. Three of eight received blood transfusion after rFVIIa administration. None required further intervention to control hemorrhage. No thromboembolic complications were noted.
	Felfernig 2007[25]	A retrospective review of 45 cases of military trauma that received rFVIIa. The median dose given was 74 mcg/kg. There were statistically significant reductions in median pRBC and FFP transfusion requirements after administration of rFVIIa. There were statistically significant improvements in median aPTT, PT, and fibrinogen values after administration of rFVIIa
	Isbister et al. 2008[26]	A retrospective review of an Australian and New Zealand registry of nonhemophiliac use of rFVIIa. Six hundred and ninety-four cases were reported. Eighty-two per cent of cases were surgical in nature and the remainder were medical and obstetric. The median dose given was 90.6 mcg/kg. There were significant reductions in all types of blood product after administration of rFVIIa. PT and INR were significantly reduced in all case types. [illegible]
	[illegible] 2003[14]	[illegible] life-threatening bleeding. Three of five patients had successful control of hemorrhage leading the authors to conclude that rFVIIa shows promise in the treatment of exanguinating hemorrhage.
	Kenet et al. 1999[30]	A 60 μg/kg dose with a repeated dose in 1 hour resulted in immediate cessation of oozing from all wound surfaces with normalization of coagulation tests.
	Mayo et al. 2004[31]	1) Thirteen patients received rFVIIa for acute, uncontrolled life-threatening hemorrhage resulted in cessation or reduction of bleeding after rFVIIa infusion. 2) Concluded transfusion replacement should aim to correct coagulopathy before infusion of rFVIIa and that a hematologist/transfusion specialist should be involved in patient management.
	O'Connell et al. 2003[32]	Retrospective analysis of data obtained from a voluntary drug surveillance database showed that 80% of those patients given rFVIIa had a decrease or cessation of bleeding with a significant decrease in blood products used.
	O'Neill et al. 2002[33]	1) Reported the efficacy of a single dose of rFVIIa in a 24-year-old multistab wound patient. 2) Concluded rFVIIa to be an effective management option in trauma patients with refractory bleeding due to ongoing coagulopathy.
	Eikelboom et al. 2003[34]	Reported a case series of 21 patients noting a drop in blood products used and a significant decrease in both PTT and INR with rFVIIa usage.

RBC, red blood cell; ISS, injury severity score; pRBC, packed red blood cells; INR, international normalized ratio; TBI, traumatic brain injury; FFP, fresh frozen plasma; GCS, Glasgow Coma Scale; aPTT, PTT, partial thromboplastin time; PT, [illegible]



PLATELET-DEPENDANT MECHANISM
Vessel injury
TF-DEPENDANT MECHANISM
collagen exposed
platelet aggregation
TF
TF
TF
TF
rfVIIa
activated platelet
VIIIa
+
IXa
IX
X
V
Va
+
Xa
X
X
Xa
+
Va
II
prothrombin
IIa
thrombin
thrombin burst

Doesn't Work if...

acidosis

hypothermia

inadequate resus

(FFP, Cryo, PLT)

Corrects INR

but what does it mean

$1 per mcg

Don’t worry about it… not an ED Drug

Prothrombin Complex Concentrates (PCC)

Antifibrinolytics

Tranexamic Acid

CRASH2

Lancet **2010;376(9734):23 - 32**

Tranexamic Acid

1g over 10 minutes
followed by infusion
1 g over 8 hours

	Tranexamic acid allocated	Placebo allocated	Risk ratio (99% CI)
Time from injury (h)			
≤1	509/3747 (13·6%)	581/3704 (15·7%)	0·87 (0·75–1·00)
>1–≤3	463/3037 (15·2%)	528/2996 (17·6%)	0·87 (0·75–1·00)
>3	491/3272 (15·0%)	502/3362 (14·9%)	1·00 (0·86–1·17)
χ^2_2=4·411; p=0·11			
Systolic blood pressure (mm Hg)			
≥90	702/6878 (10·2%)	736/6761 (10·9%)	0·94 (0·82–1·07)
76–89	280/1609 (17·5%)	313/1689 (18·5%)	0·94 (0·78–1·14)
≤75	478/1562 (30·6%)	562/1599 (35·1%)	0·87 (0·76–0·99)
χ^2_2=1·345; p=0·51			
GCS			
Severe (3–8)	796/1789 (44·5%)	860/1830 (47·0%)	0·95 (0·86–1·04)
Moderate (9–12)	219/1349 (16·2%)	249/1344 (18·5%)	0·88 (0·70–1·09)
Mild (13–15)	447/6915 (6·5%)	502/6877 (7·3%)	0·88 (0·75–1·04)
χ^2_2=1·387; p=0·50			
Injury type			
Blunt	1134/6788 (16·7%)	1233/6817 (18·1%)	0·92 (0·83–1·02)
Penetrating	329/3272 (10·1%)	380/3250 (11·7%)	0·86 (0·72–1·03)
χ^2_1=0·791; p=0·37			
All patients	**1463/10 060 (14·5%)**	**1613/10 067 (16·0%)**	**0·91 (0·85–0·97)***
Two-sided p=0·0035			

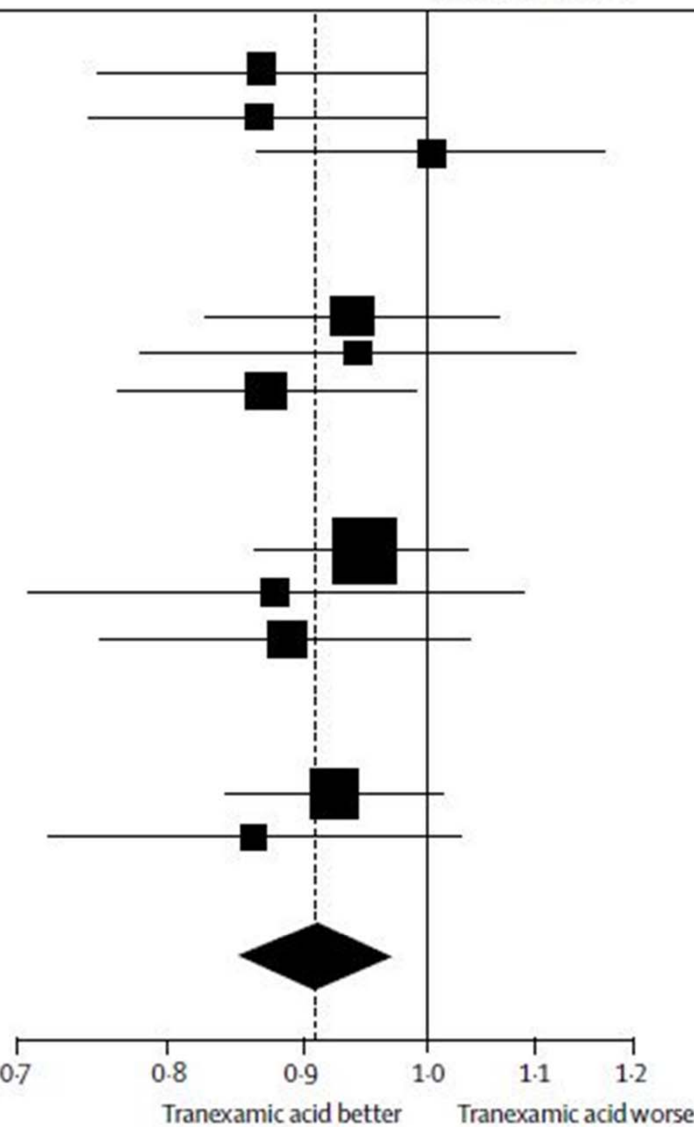


***Figure 3*: All-cause mortality by subgroups**

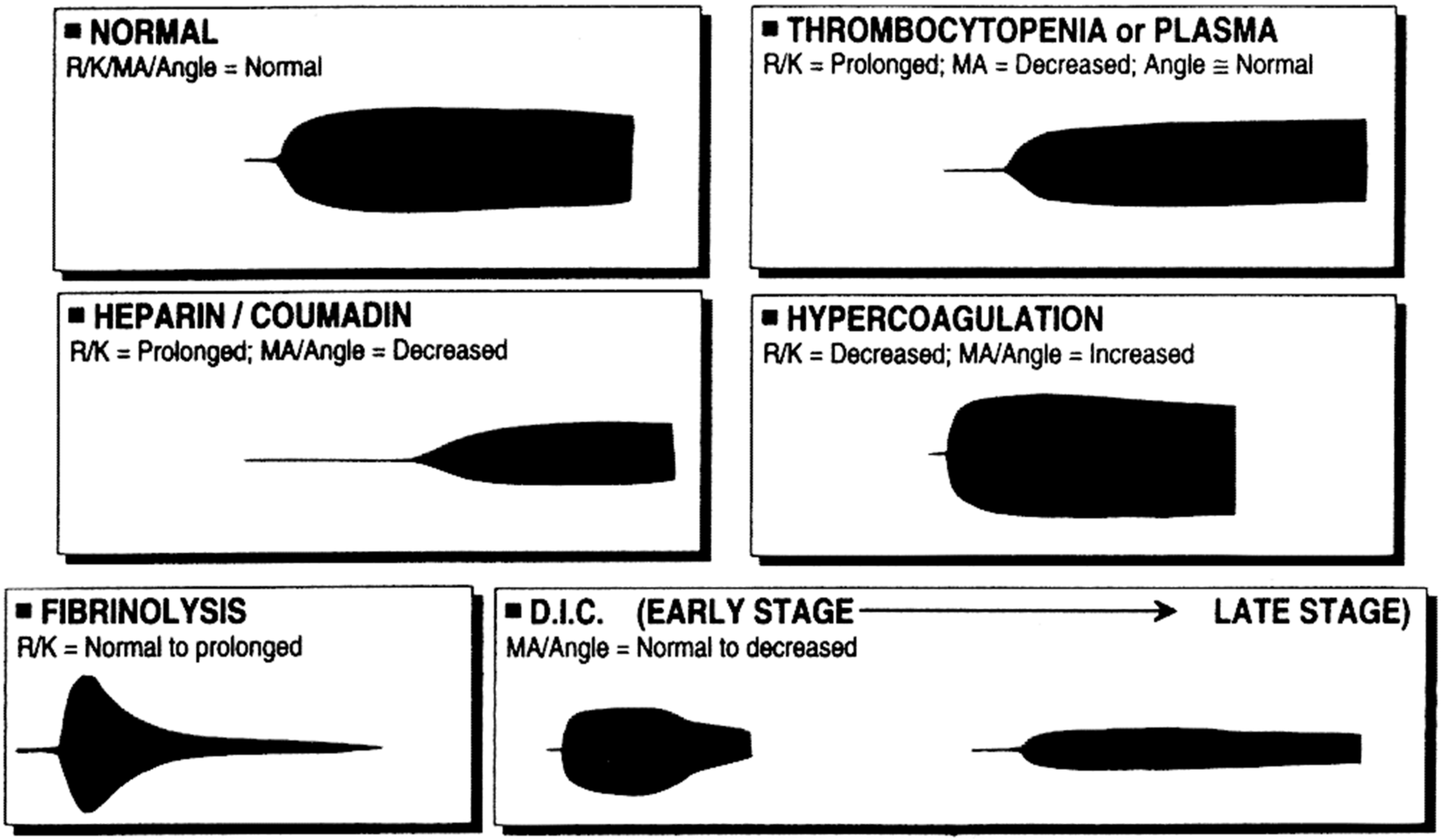
GCS=Glasgow Coma Score. *95% CI.

No increase in thrombosis

but how does it work?

Individualized Hemostatic Resuscitation

TEG


NORMAL
R/K/MA/Angle = Normal
THROMBOCYTOPENIA or PLASMA
R/K = Prolonged; MA = Decreased; Angle ≅ Normal
HEPARIN / COUMADIN
R/K = Prolonged; MA/Angle = Decreased
HYPERCOAGULATION
R/K = Decreased; MA/Angle = Increased
FIBRINOLYSIS
R/K = Normal to prolonged
D.I.C. (EARLY STAGE → LATE STAGE)
MA/Angle = Normal to decreased


PRBC / Hb Substitutes
PCC
Fibrinogen Concentrate
Hypertonic Saline
Platelets, Anti-fibrinolytics,
Additional PCC & Calcium PRN
Guided By TEG & Labs

Review

Permissive Hypotension

Minimal Normotension

Bust ‘da Clot Theory & Dilutional Coagulopathy

Evidence

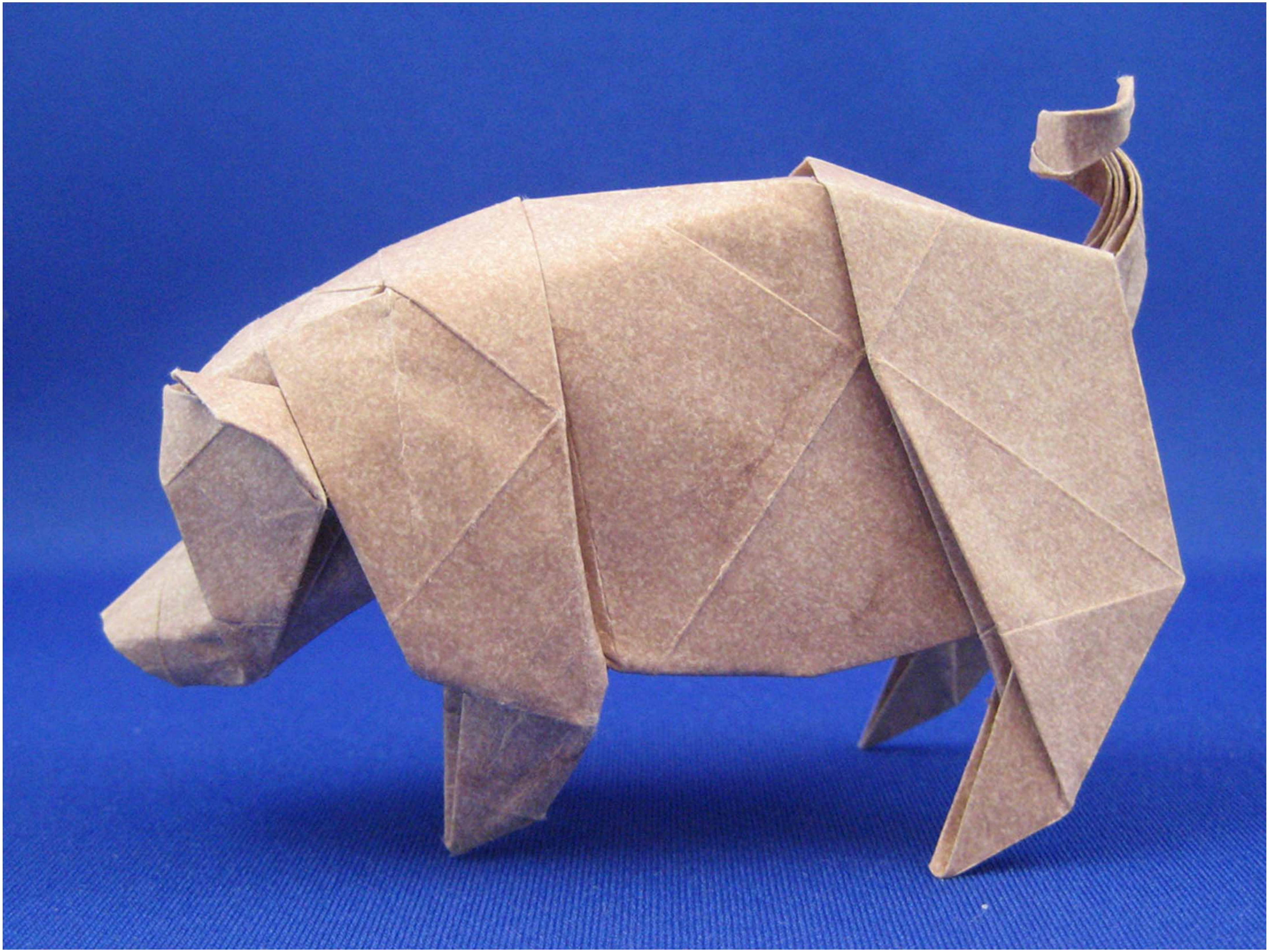
The NEW ENGLAND JOURNAL of MEDICINE

ORIGINAL ARTICLE

Immediate versus Delayed Fluid Resuscitation for Hypotensive Patients with Penetrating Torso Injuries

William H. Bickell, Matthew J. Wall Jr., Paul E. Pepe, R. Russell Martin, Victoria F. Ginger, Mary K. Allen and Kenneth L. Mattox

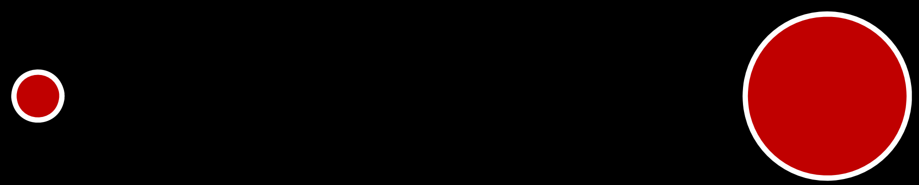
N Engl J Med 1994; 331:1105-1109 | October 27, 1994



65

65 + Perfusion

All with MAP of 65



**Vasoconstricted,
Empty Tank**

**Filled
Tank**

65 + Perfusion + Pain Control & Sedation

How does this play out?

UTS Femoral A-Line

Davis. J Trauma 2003;55:860

Good Pulse OX
Radial Pulse

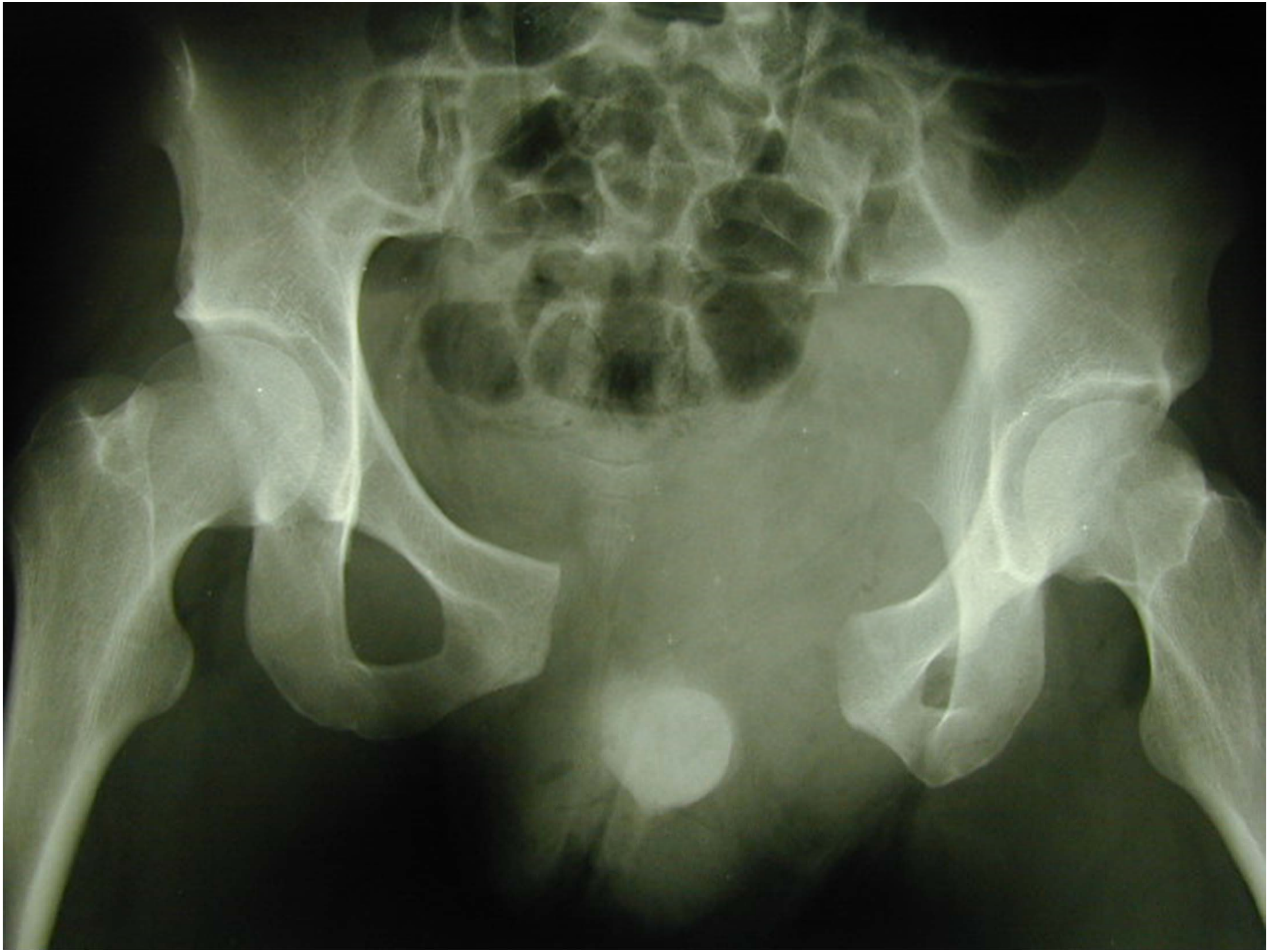
Fentanyl Aliquots

review

Non-Compressible Wounds


Scalp Lacs

Pelvic Fractures



Femur Fractures

Non-Compressible Soft Tissue Injuries

HemCon

QuickClot


QuikClot
Adsorbent Hemostatic Agent
Temporary Traumatic Wound Treatment
To Stop Moderate-to-Severe Bleeding
By Promoting Rapid Coagulation
FOR EMERGENCY EXTERNAL USE
Do Not Eat
~ See Directions On Back ~
Z-MEDICA

WoundStat

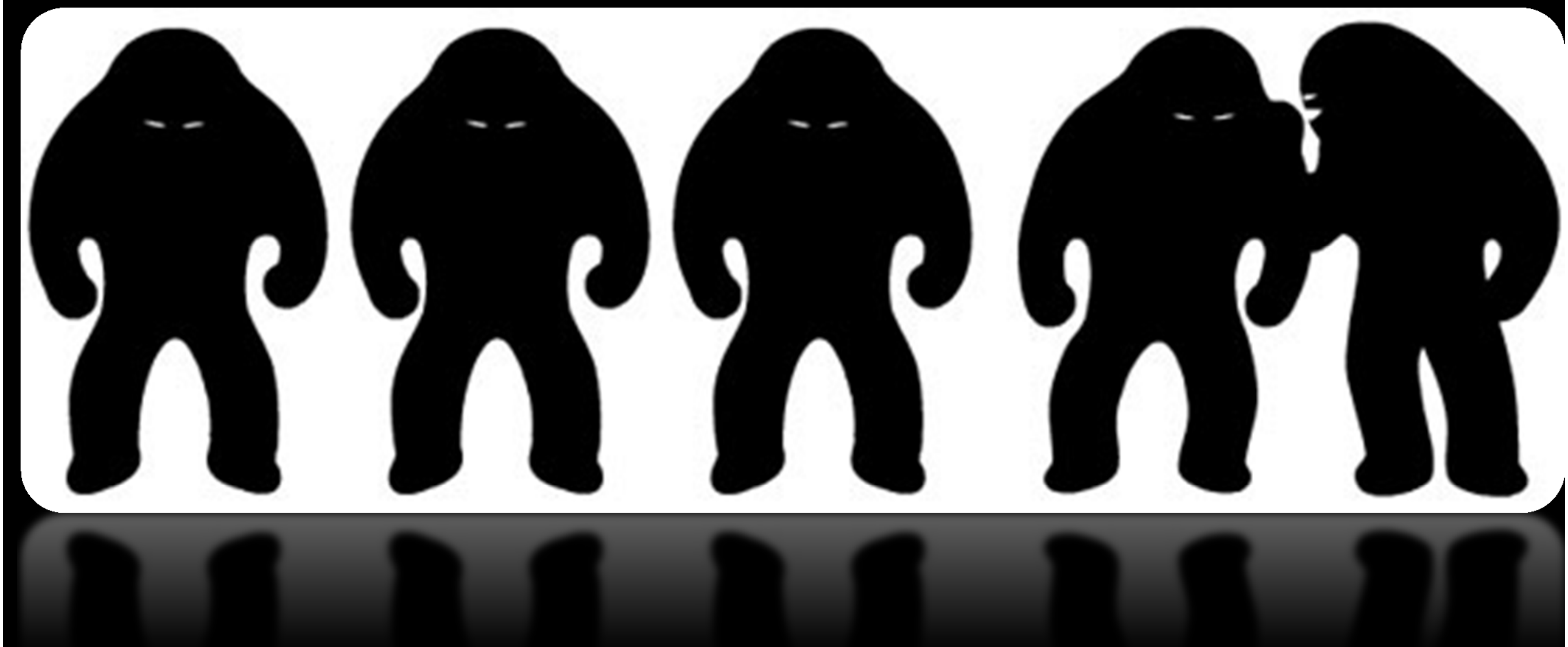
Combat Gauze

Extremity Vascular Injuries

Tourniquets


20
40
60
80
100
120
140
160
180
200
220
240
260
280
300

To Review



References & Handout


EMCrit
Podcast
blog.emcrit.org


Trauma is a bear
eat bear world
We can only
attempt to Control
the Damage