Hemostasis for the Field Provider

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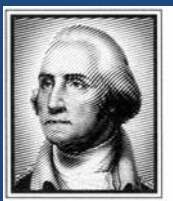

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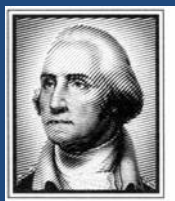
Disclosures

- None



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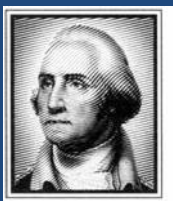
Objectives

- Discuss coagulopathy related to trauma
- Review novel topical hemostatic agents
- Review data for tourniquets



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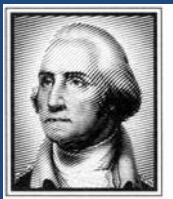
Background

- Hemorrhage is the second leading cause of death in trauma
- Hemorrhage is the lead cause of preventable death in trauma



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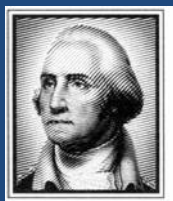
Prevalence of Uncontrolled Bleeding

Surgical Discipline	Uncontrolled Bleeding Rate
Cardiovascular	5%–7% Post-op[1]
General	1.9% Laparoscopic cholecystectomy[2]
Obstetric	3.9% (vaginal); 6.4% (cesarean)[3,4]
Orthopedic	2%–6.3% Hip/knee arthroplasty[5-7]
Urologic	4%–8% TURP[8]; 3.3%-9.9% URL[9]
Trauma	30%–40%[10,11]

1. Despotis GJ, et al. *Ann Thorac Surg*. 2000;70:S20-S32; 2. Erol DD, et al. *The Internet Journal of Anesthesiology*. 2005;9:2; 3. Combs CA, et al. *Obstet Gynecol*. 1991;77:69-76; 4.Combs CA, et al. *Obstet Gynecol*. 1991;77:77-82; 5. Hull R, et al. *N Engl J Med*. 1993;329:1370-1376; 6. Leclerc JR, et al. *Ann Intern Med*. 1996;124:619-626; 7. Strebel N, et al. *Arch Intern Med*. 2002;162:1451-1455; 8. Daniels PR. *Nat Clin Pract Urol*. 2005;2:343-350; 9.Rosevear HM, et al. *J Urol*. 2006;176:1458-1462; 10. Holcomb JB. *Crit Care*. 2004;8(suppl 2):S57-S60; 11. Sauaia A, et al. *J Trauma*. 1995;38: 185-193.



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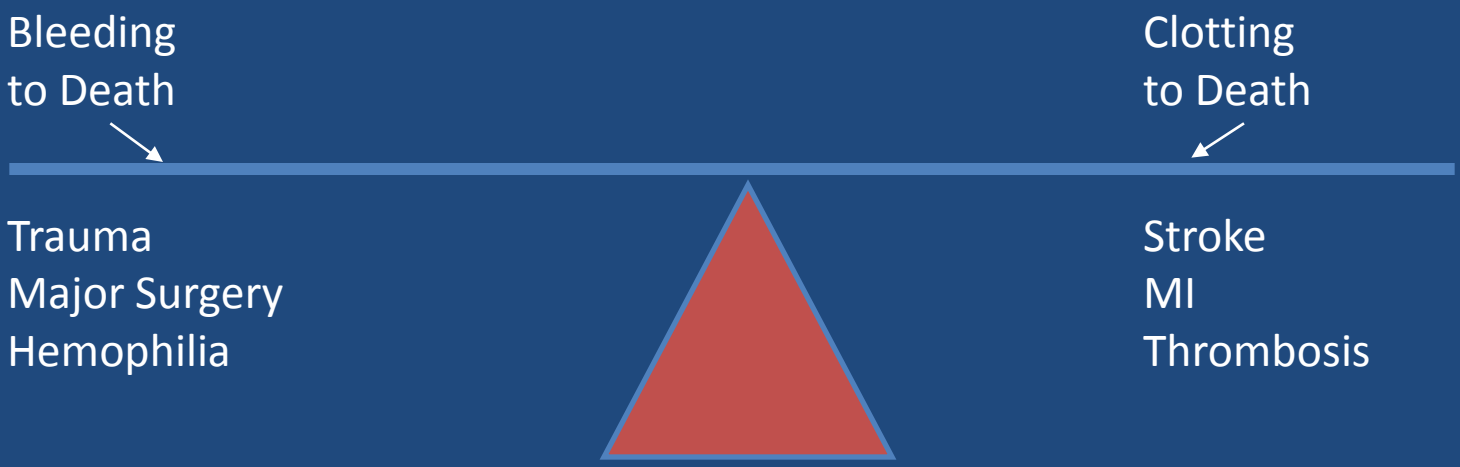
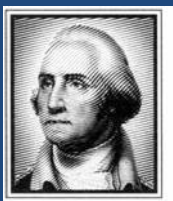
Hemostasis
"Life in the Balance"



Lawson JH, et al. *Semin Hematol.* 2004;41(suppl 1):55-64.

The Hemorrhaging Patient

- The Basics
  - Direct Pressure, splint fractures
  - Rapid Transport, Minimize fluids
  - Tourniquets (stay tuned)



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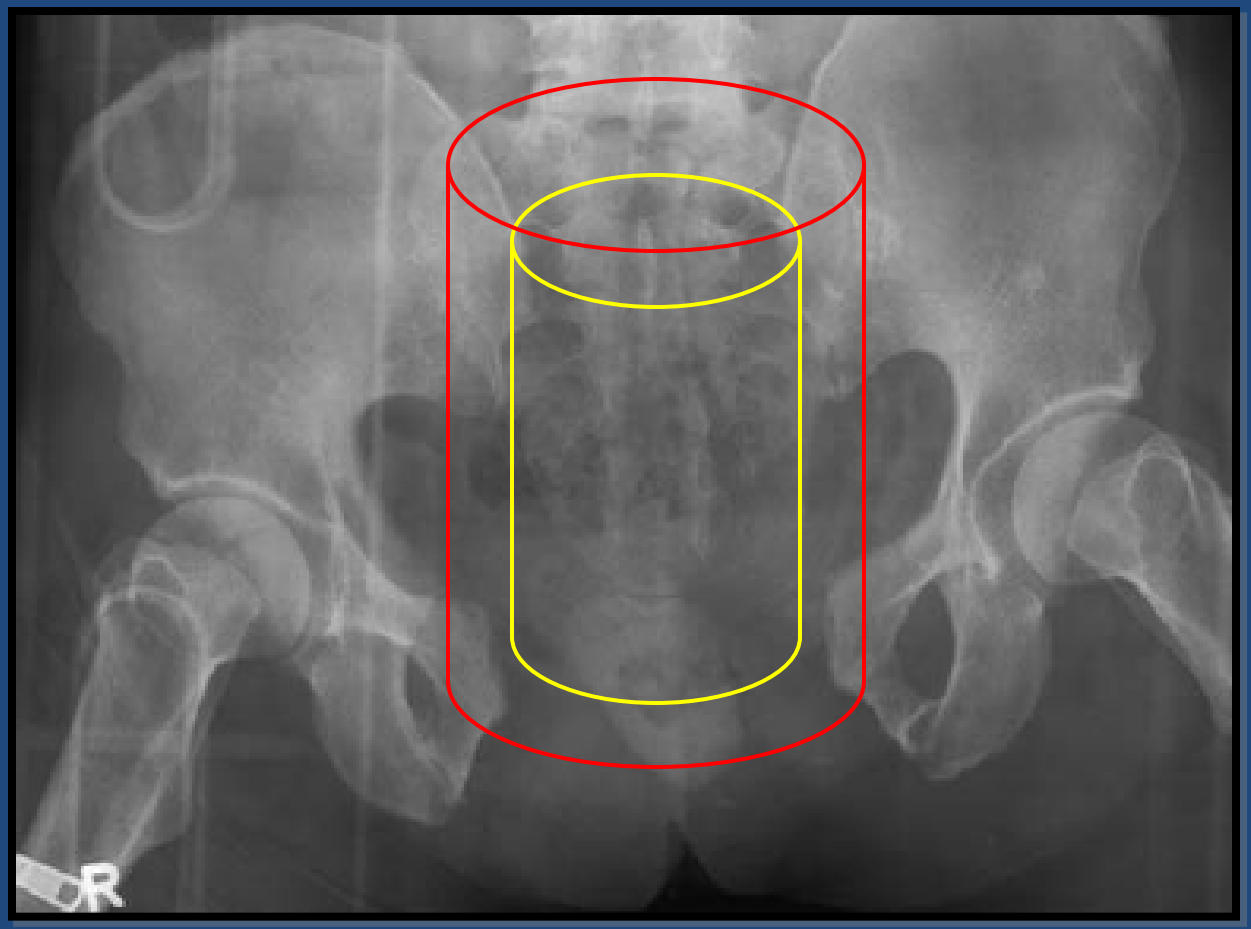
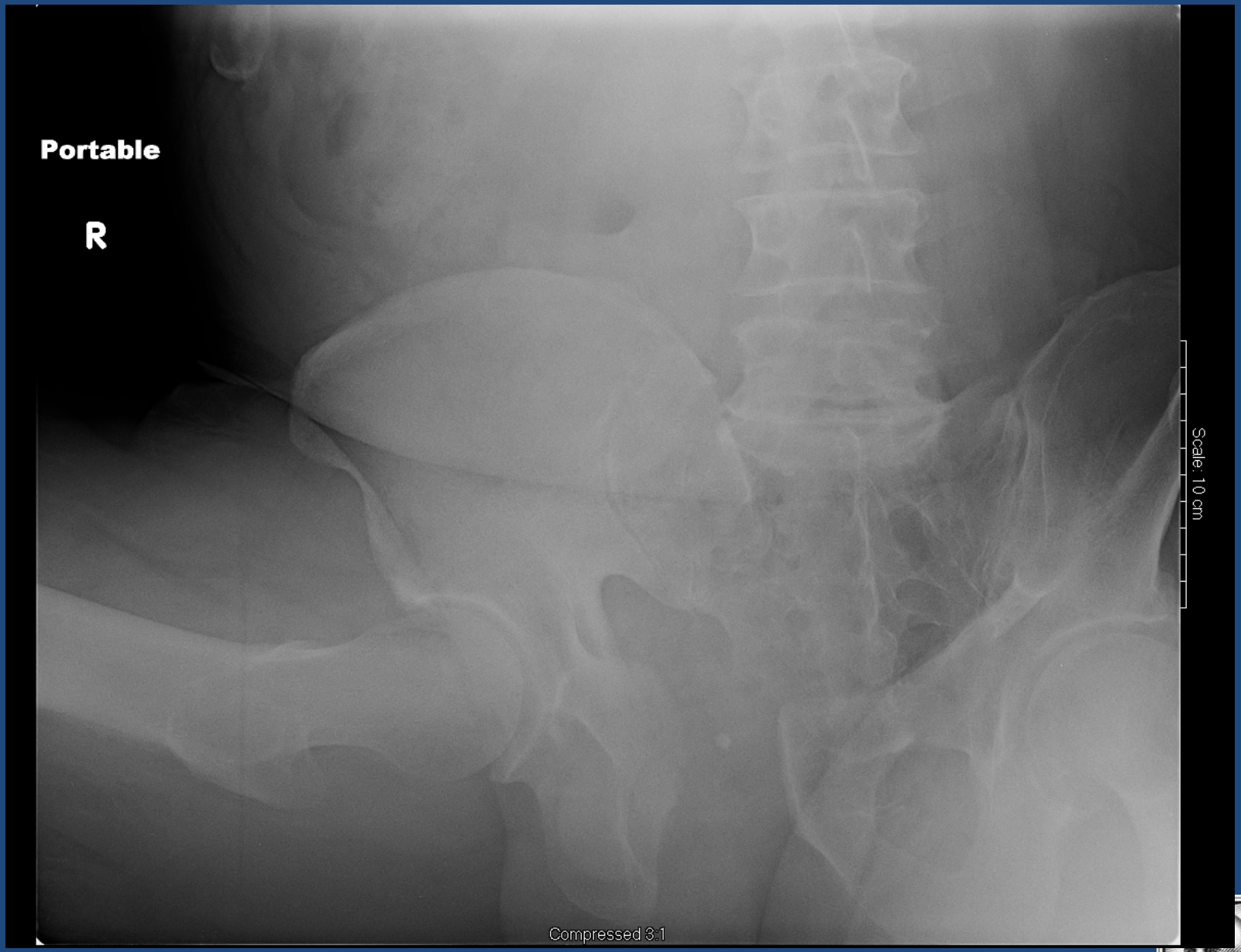
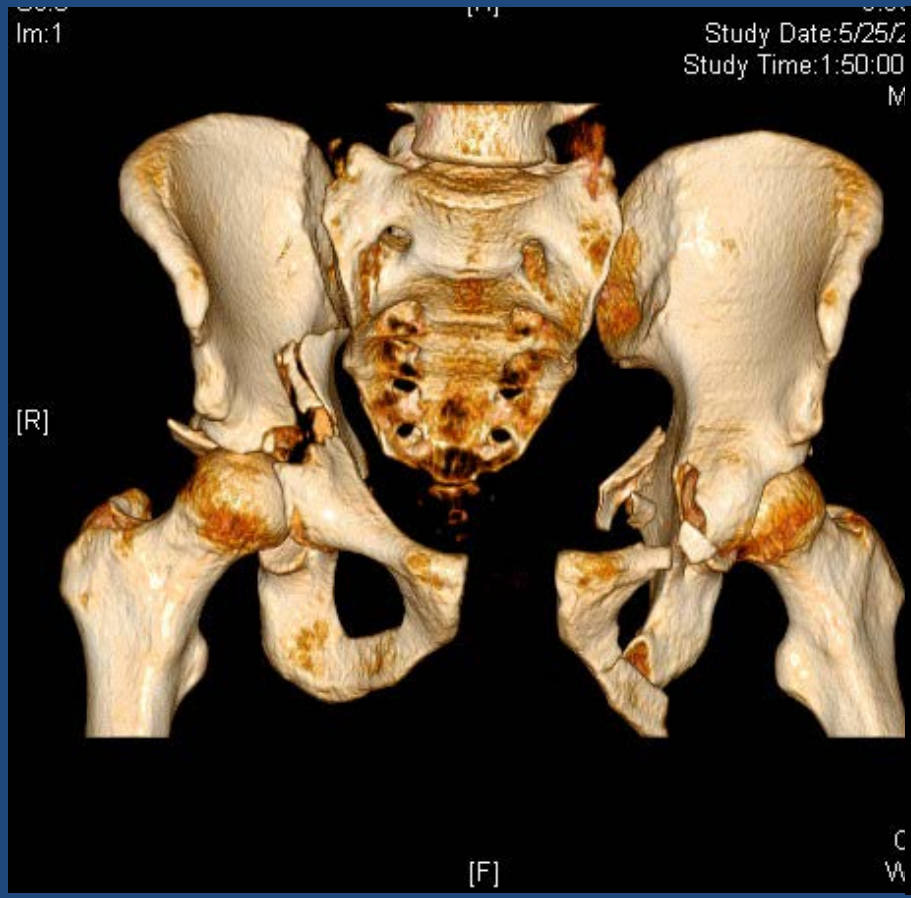
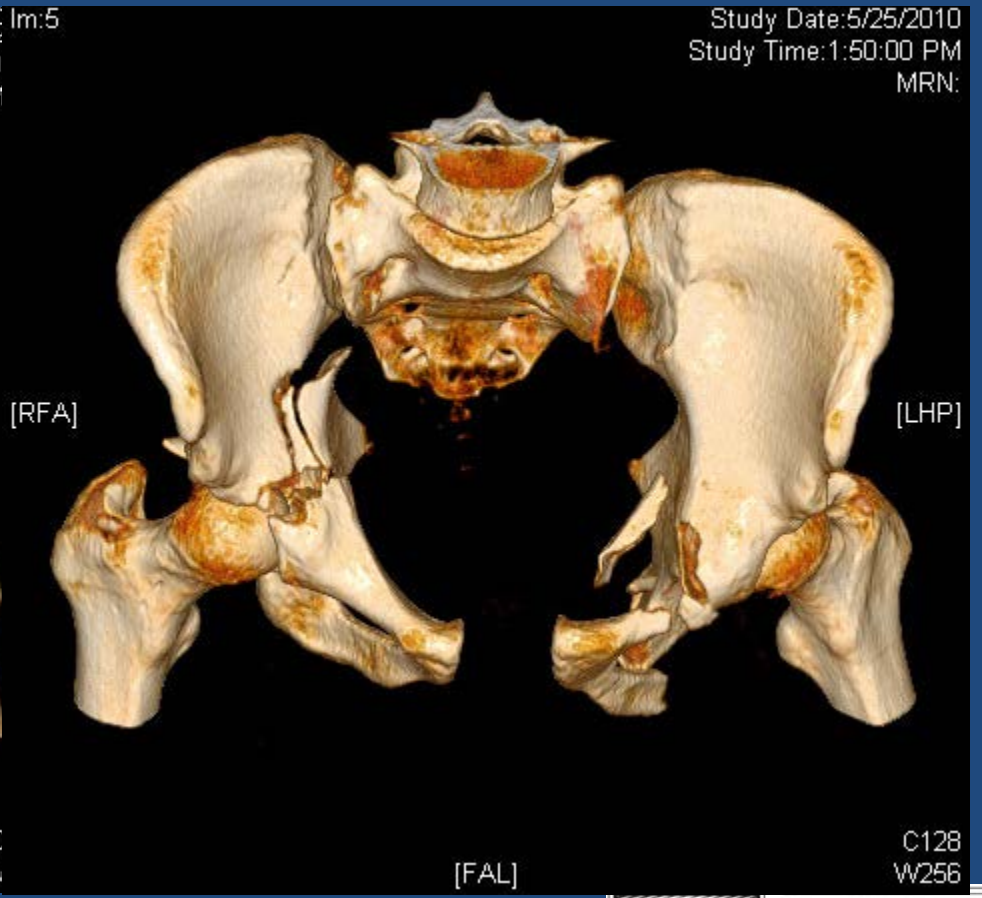
Reducing Fractures Stops Bleeding

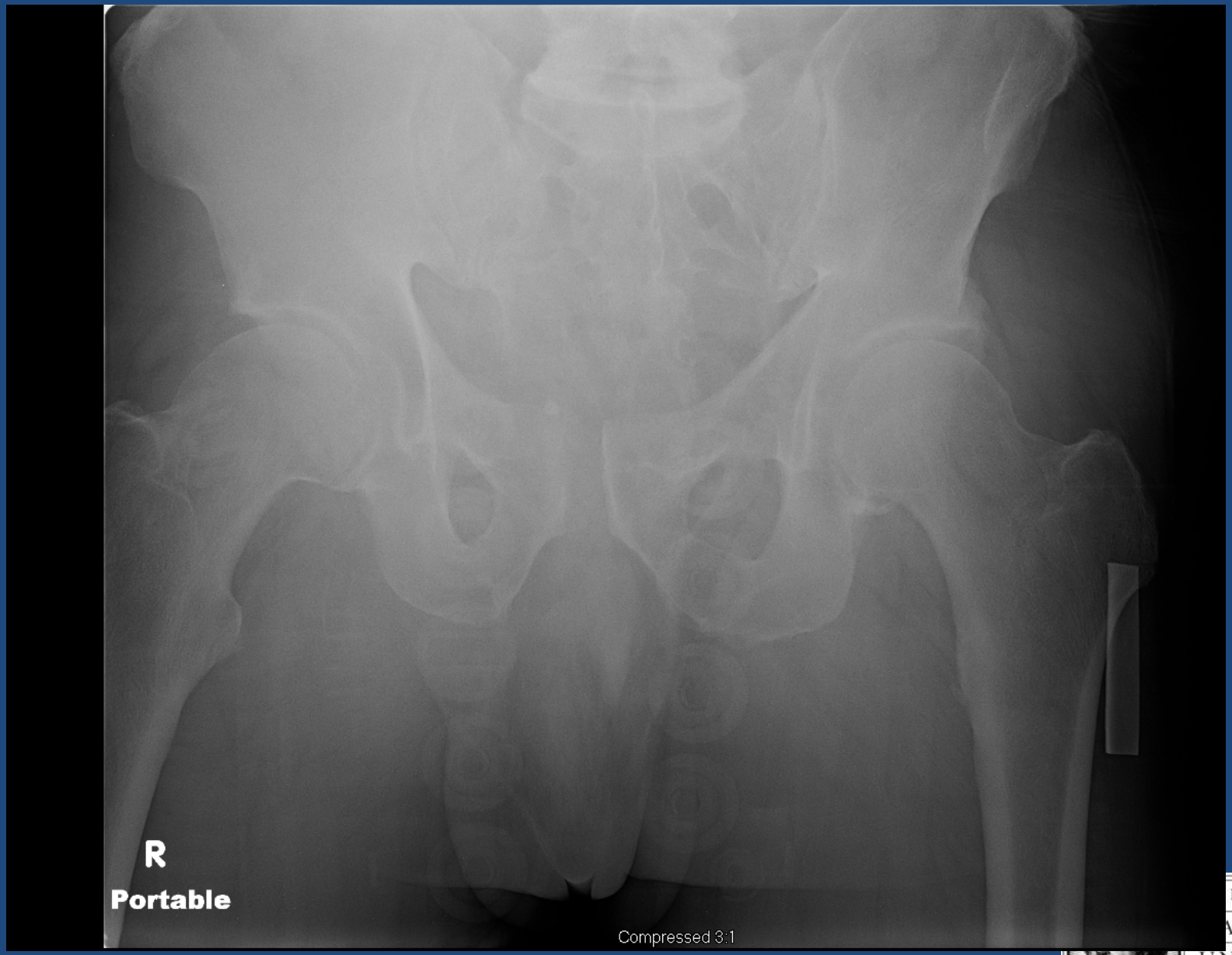




Open Book Pelvis Fracture



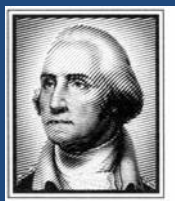




Resuscitating the Bleeding Patient

- Lethal Triad of Trauma
  - Hypothermia < 34
  - Acidosis < 7.1
  - Coagulopathy > 2

98% Mortality (w/o damage control)



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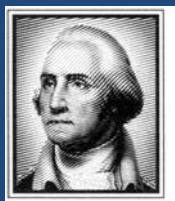
Addressing Coagulopathy

- Blood-based resuscitation
  - Military reports
  - Minimize cystalloid
  - Rapid transport to FST for blood based therapy
- Permissive hypotension
  - SBP 80-90 mmHg for penetrating trauma
  - SBP 120 mmHg for head injury



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Hypotension Resuscitation

Table 4. Total Volumes of Fluids Administered to Patients with Penetrating Torso Injuries, According to Treatment Group.*

Variable	Immediate Resuscitation (N = 309)	Delayed Resuscitation (N = 289)	P Value
Before arrival at the hospital			
Ringer's acetate (ml)	870±667	92±309	<0.001
Trauma center			
Ringer's acetate (ml)	1608±1201	283±722	<0.001
Packed red cells (ml)	133±393	11±88	<0.001

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

NEJM 1994; 331 (17): 1105-9

Special Commentary

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

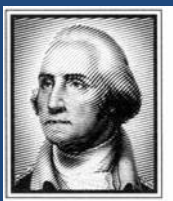
Damage Control Resuscitation: Directly Addressing the Early Coagulopathy of Trauma

John B. Holcomb, MD, FACS, Don Jenkins, MD, FACS, Peter Rhee, MD, FACS, Jay Johannigman, MD, FS, FACS, Peter Mahoney, FRCA, RAMC, Sumeru Mehta, MD, E. Darrin Cox, MD, FACS, Michael J. Gehrke, MD, Greg J. Beilman, MD, FACS, Martin Schreiber, MD, FACS, Stephen F. Flaherty, MD, FACS, Kurt W. Grathwohl, MD, Phillip C. Spinella, MD, Jeremy G. Perkins, MD, Alec C. Beekley, MD, FACS, Neil R. McMullin, MD, Myung S. Park, MD, FACS, Ernest A. Gonzalez, MD, FACS, Charles E. Wade, PhD, Michael A. Dubick, PhD, C. William Schwab, MD, FACS, Fred A. Moore, MD, FACS, Howard R. Champion, FRCS, David B. Hoyt, MD, FACS, and John R. Hess, MD, MPH, FACP

J Trauma. 2007;62:307–310.

"Prolongation of the PT is the sentinel event…and occurs early in the operation"

J Trauma 2003



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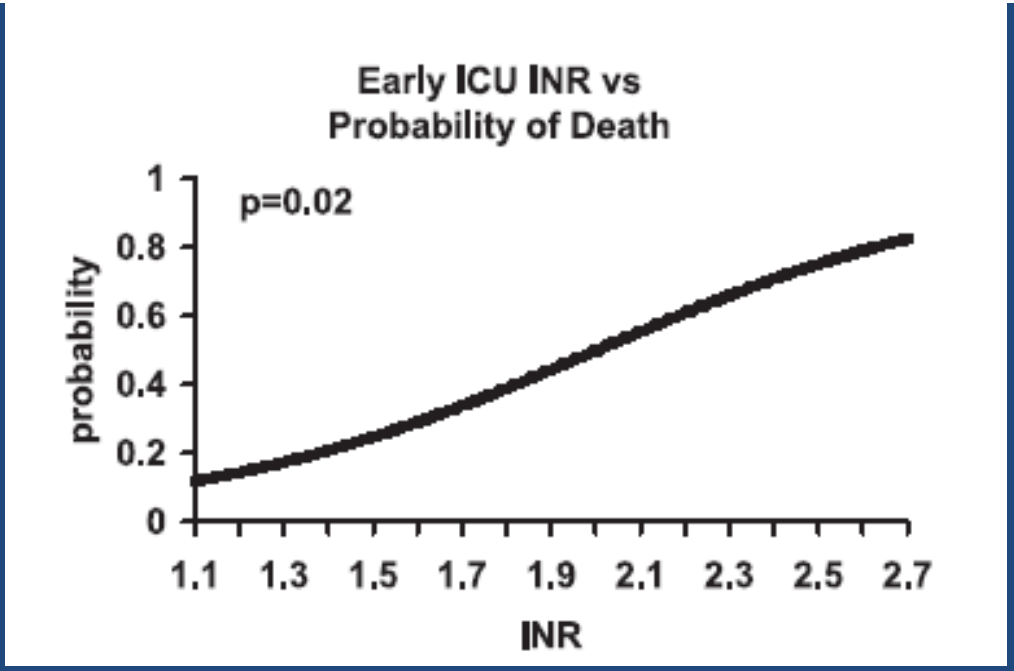
The Journal of **TRAUMA**® *Injury, Infection, and Critical Care*

Fresh Frozen Plasma Should be Given Earlier to Patients Requiring Massive Transfusion

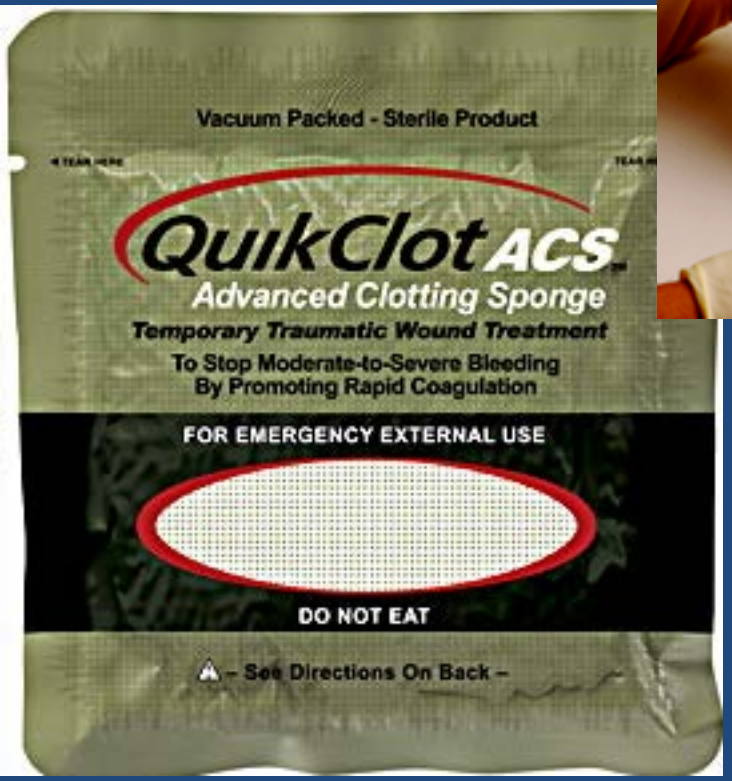
Ernest A. Gonzalez, MD, Frederick A. Moore, MD, John B. Holcomb, MD, Charles C. Miller, PhD, Rosemary A. Kozar, MD, PhD, S. Rob Todd, MD, Christine S. Cocanour, MD, Bjorn C. Balldin, MD, and Bruce A. McKinley, PhD

2007; 62:112



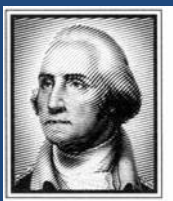
Topical Agents

WOUNDSTAT



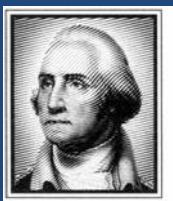
Topical Agents

- Mechanical only
  - Gauze – matrix for clot formation
- Mechanical and inherent hemostatic capability
  - Tissue factor activators
  - Induce Hypercoagulable State



Topical Agents

- Characteristics:
  - Stop large arterial vessel bleeding < 3 minutes
  - No need to mix/reconstitute
  - Light weight
  - Long/indefinite shelf life in extreme setting
  - Safe/no infectious concerns
  - Inexpensive



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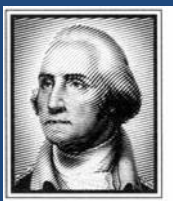
Mechanisms

- Mucoadhesive agents
  - Chitosan based: Celox, HemCon
  - Plug the hole
- Factor concentrates
  - QuikClot
  - Create a hypercoagulable environment
- Procoagulant supplementation
  - Dressing with imbedded procoagulant factors

- All require 3-5 minute hold
- All must be removed (non-absorbable)



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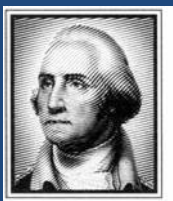
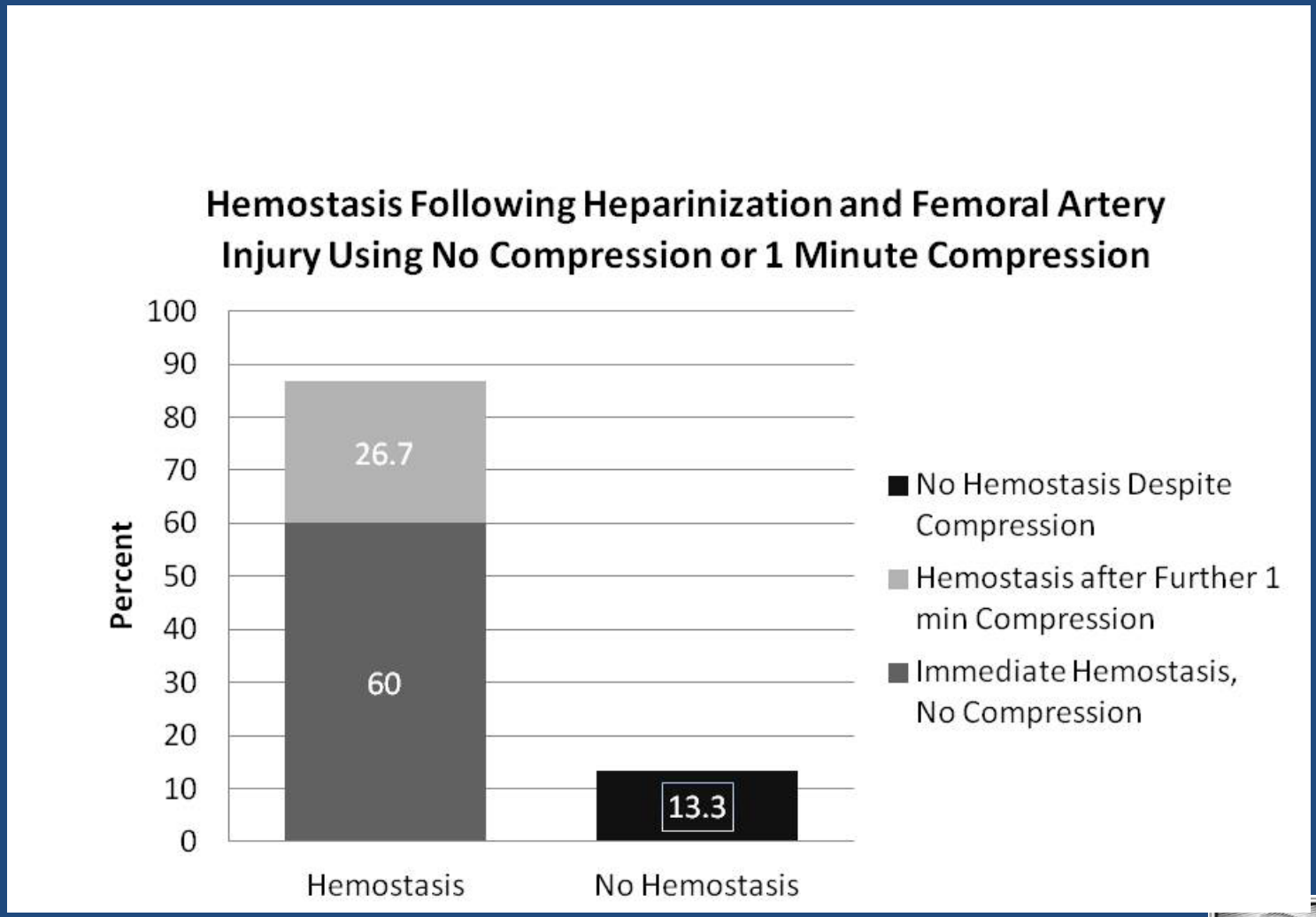
Mucoadhesive Agents HemCon/Chitoflex/Celox

- Chitosan based product that adheres to the bleeding surface and seals it
  - Supposed to work in coagulopathy because it plugs the hole
  - Must be in firm contact with the bleeding surface
- Bacteriostatic



Celox: Heparinized Porcine Model



Not published

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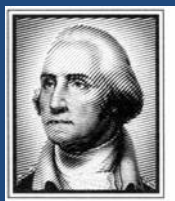
Factor Concentrates
QuikClot

- Zeolite (volcanic rock)
  - Absorbs water to make the local area hypercoagulable
  - Poor outcome in coagulopathic patient



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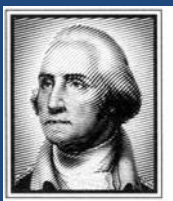
QuikClot

Table 3 Post-Injury Effects of Control (gauze) and QuikClot Treatments

Variable	Gauze	QuikClot	*p* Value of Difference
Post-treatment blood loss (ml)	5338 ± 806	1397 ± 806	<0.01
Resuscitation fluid used (ml)	9686 ± 1260	5574 ± 1260	0.04
Peak temperature at tissue interface (°C)	37.5 ± 0.01	93.3 ± 10.5	<0.01
Survival	1/8 (12%)	7/8 (88%)	<0.01
Survival time (min)	44.5 ± 3.6	58.3 ± 1.8	<0.01

J Trauma 2004; 57 : 555-562



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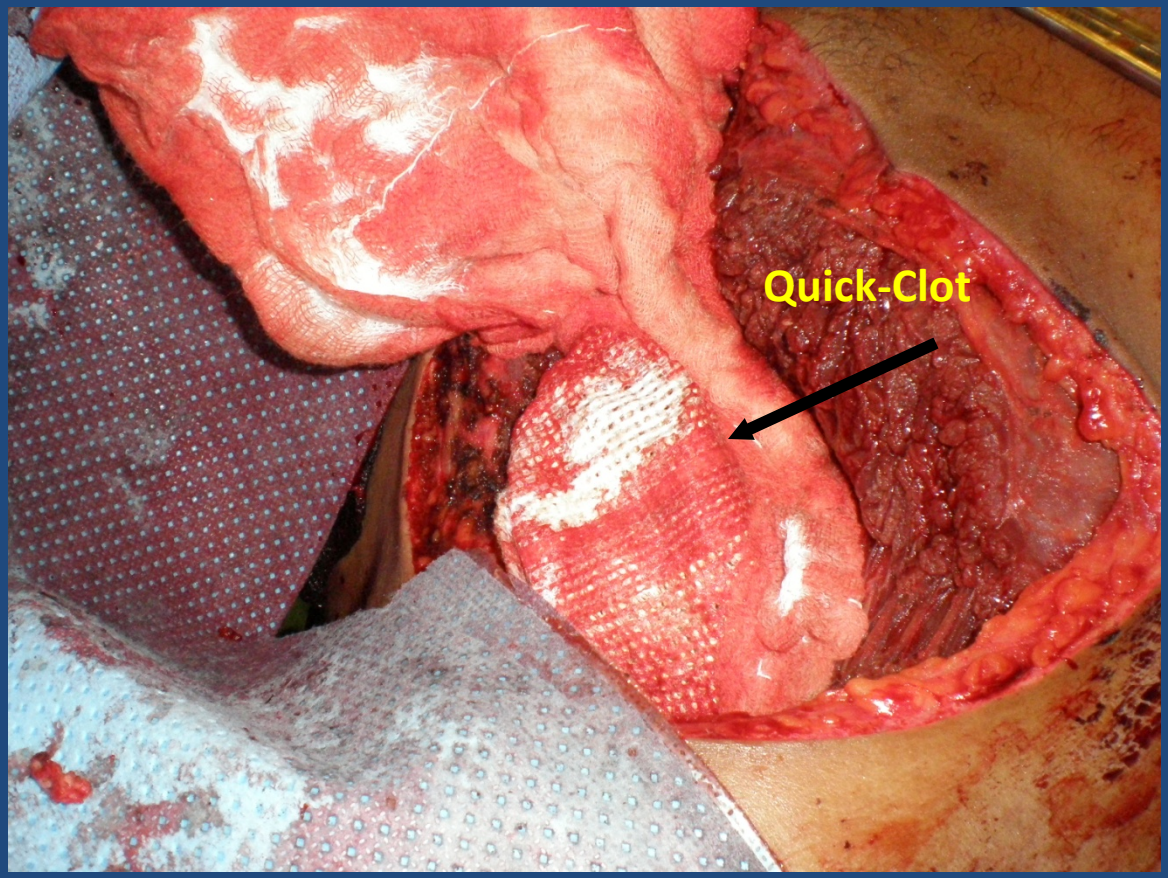
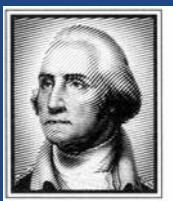
Hemostatic Dressings



Procoagulant Supplement
Combat Gauze

- Woven gauze impregnated with Kaolin
  - Activates clotting process
  - Must be in dense contact with bleeding surface
    - Hold for 3-5 minutes
  - May not be effective in coagulopathic patient



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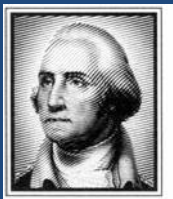
Evidence/Trials

- No prospective studies
- Retrospective, uncontrolled data
- Animal data



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In Vitro Effects of Topical Agents on Coagulation

TEG analysis of blood mixed with agents

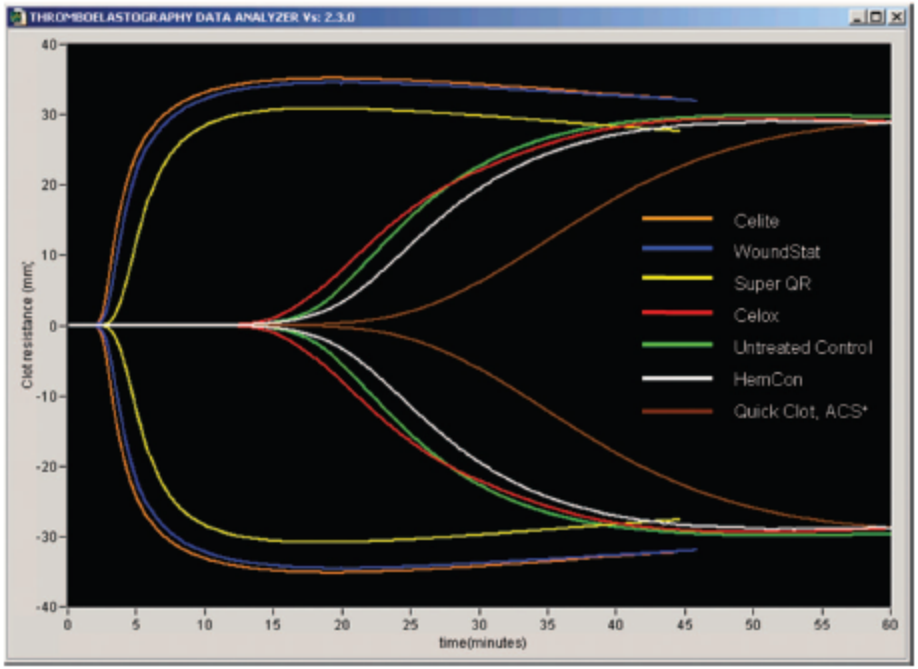
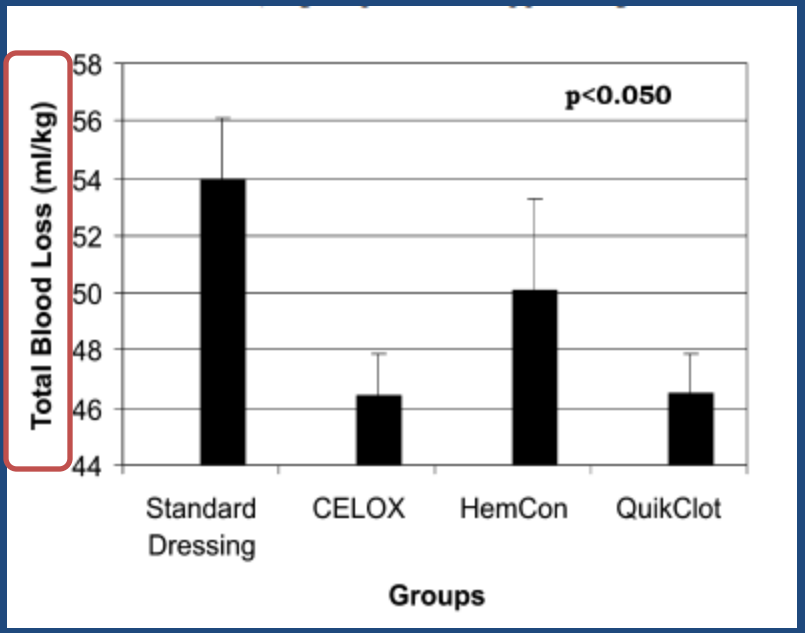
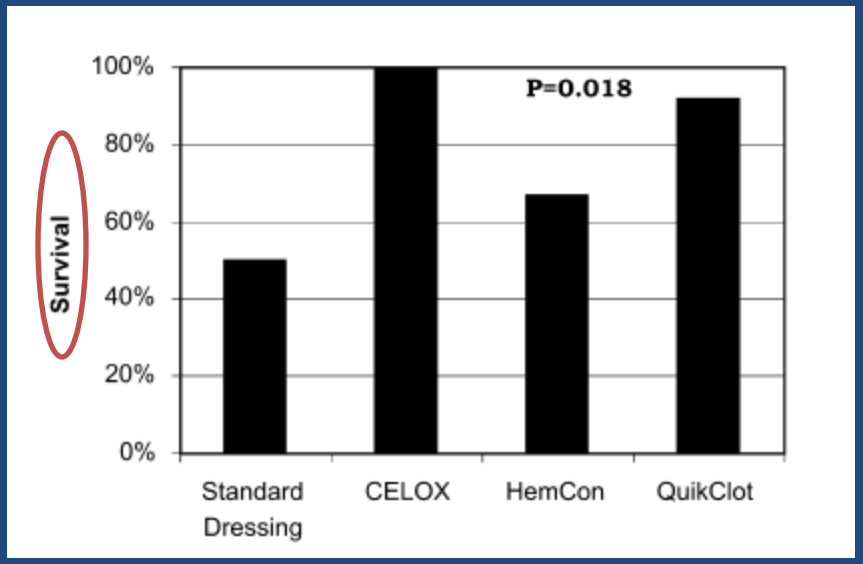


Fig. 7. *The average thrombograms of pig blood after treatment with different hemostatic agents. Two milliliter of blood samples were mixed with 9 mg of each agent and assayed after addition of calcium chloride. The agents were compared with a known contact pathway activators (Celite) and untreated blood (control).*

Kheirabadi et al. J Trauma 2009; 66:316-328

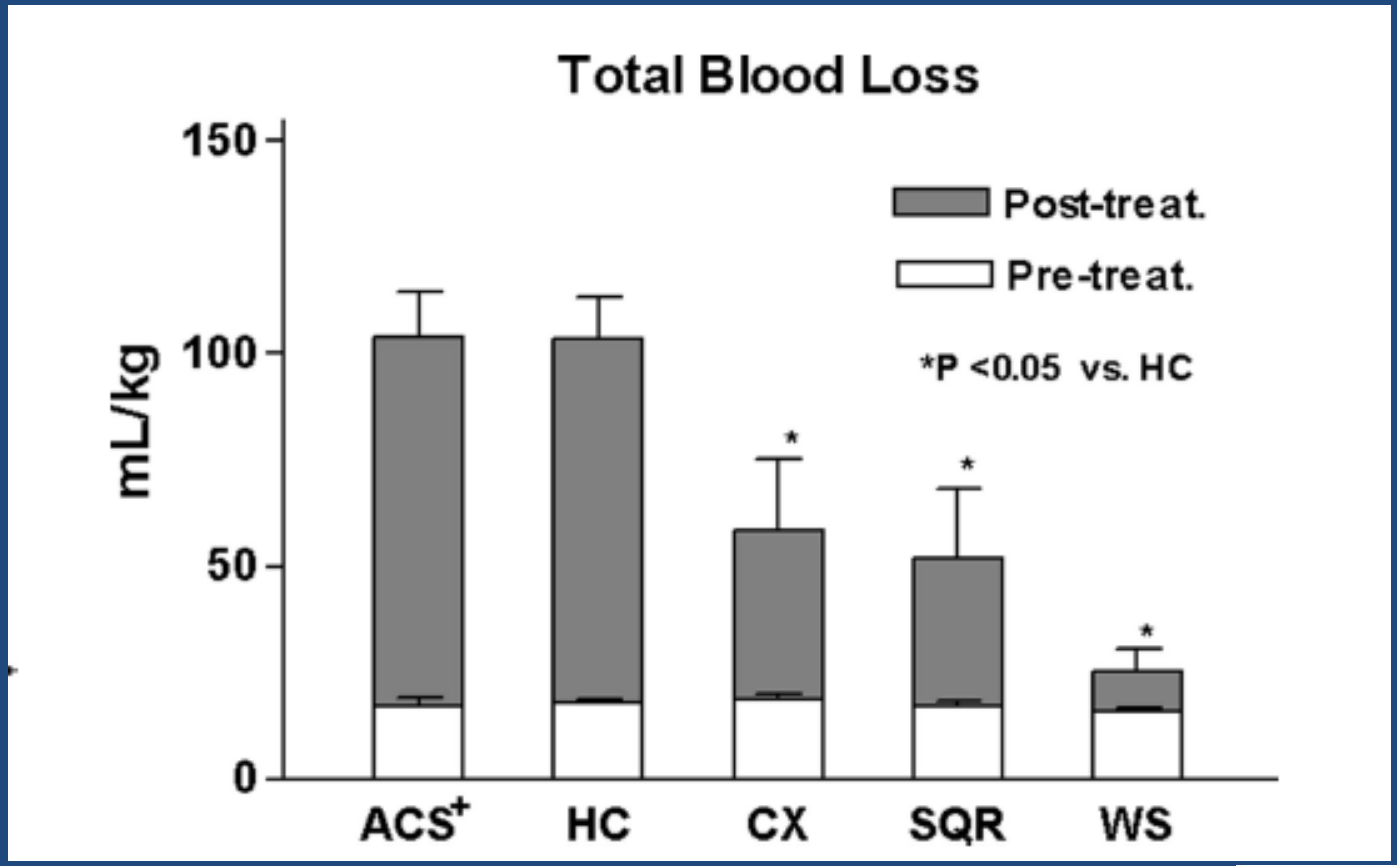
Comparison of Various Topical Hemostatics





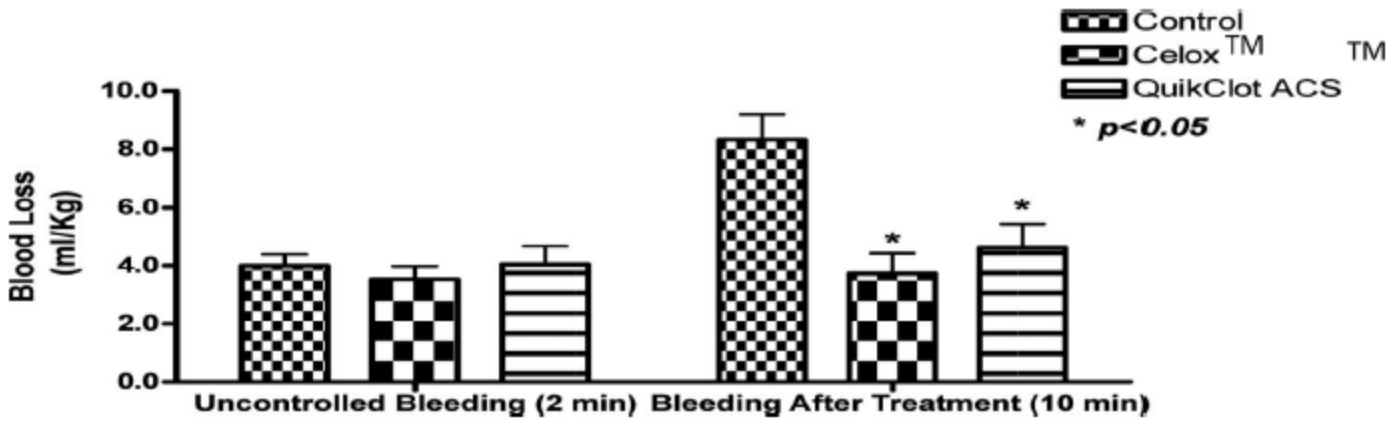
Kozen et al. Acad Emerg Med 2008; 15: 74-81

Animal Studies



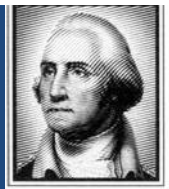
Kheirabadi et al. J Trauma 2009; 66:316-328

Liver Injury Model



In the control and QuikClot ACS+ animals that survived to reoperation, removal of the packs led to immediate rebleeding, severe enough that repacking would have been necessary in all cases. In the Celox arm, however, all but one animal had successful removal of packs and excess hemostatic agent without the need for repacking.

Inaba. J Trauma. 2011; 71(5):1312-18



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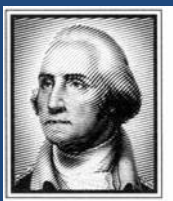
Tourniquets

Tourniquets

- **SAVE LIVES!!**
- Max time 120 minutes
- Risk factors for injury
  - Injury/Shock
  - Age
  - Vascular disease



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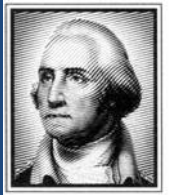
Tourniquet

- Use a wide, smooth material
- Apply to the thickest part of the extremity
- Tighten to the pressure needed to make the extremity pulseless
- Mark the time that the tourniquet was applied
  - Do NOT cover the extremity



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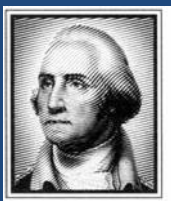
Tourniquet Use

TABLE 2. Indications for Tourniquet Use in Eemergency Medical Services (EMS) and other Prehospital Settings

Amputation
Failure to stop bleeding with pressure dressing(s)
Injury does not allow control of bleeding with pressure dressing(s)
Significant[a] extremity hemorrhage in the face of any or all of:
Need for airway management
Need for breathing support
Circulatory shock
Need for other emergent interventions or assessment
Bleeding from multiple locations
Impaled foreign body with ongoing extremity bleeding
Under fire or other dangerous situation for responding caregivers
Total darkness or other adverse environmental factors
Mass casualty event[b]

Prehosp Emerg Care. 2008; 12(2): 241-256



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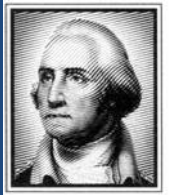
Tourniquet Use

TABLE 1. Potential Complications of Use of Tourniquets[a]

Local	Systemic
Postoperative swelling and stiffness	Increased central venous pressure
Delay in recovery of muscle power	Arterial hypertension
Compression neuropraxia	Cardiorespiratory decompensation
Wound hematoma	Cerebral infarction
Wound infection	Alterations in acid-base balance
Direct vascular injury	Rhabdomyolysis
Bone and soft-tissue necrosis	Deep venous thrombosis
Compartment syndrome	Tourniquet pain
	Systemic inflammatory response syndrome[b]
	Fibrinolysis[c]

Prehosp Emerg Care. 2008; 12(2): 241-256



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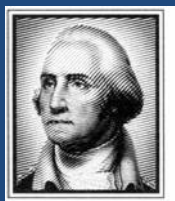
Conclusion

- 1. Minimize coagulopathy
  - Minimize fluids
  - Rapid transport to trauma center
- 2. Minimize bleeding
  - Permissive hypotension
  - Tourniquet use
  - Rapid transport to trauma center
- 3. Novel Hemostatic agents
  - Celox and Combat Gauze appear to be the best



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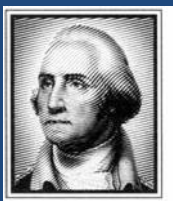
Podcast On Topical Hemostatics

- http://www.east.org/resources/traumacast-detail/28



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