Making the Most of the *Golden Hour*

Non Compressible Hemorrhage
Unmet Civilian Needs

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Trauma Deaths: When & Where

Let’s look here...

50% Traumatic Deaths Occur in the First 12 Hours
Trauma Deaths: What Decreases Mortality

46% CPR in field

52% Died in the first 12 hours

51% CNS death

9% MSOF

Journal of Trauma; 2003; 54(1): pp66-71
Injury Prevention, Not Therapy Impacts Trauma Mortality

Change Behavior/ Injury Prevention
More than 50% Reduction in Trauma Deaths

Change in Therapy
93% Not Preventable
6.8% Preventable

13 % Reduction in Trauma Deaths
Trauma Deaths: Where and When

- 556 deaths within the first hour
- Median time to arrival: 39 minutes
- Blunt: 53%
- Penetrating: 42%
- Most common cause of death: penetrating CNS injury

American Journal of Surgery; 2007

Possibly preventable:
- single organ/vessel: 38% (35 patients)

- Most: < 15 mins
- Time to intervene includes scene time

Non compressible hemorrhage?
85 deaths
• Blunt: 78
• Penetrating: 8

15 “immediate”
Trauma Deaths: Where & When
UMass Medical Center Experience

“Immediate” deaths due to on-going or irreversible process

- Post arrest: 7
- ICH/Mass: 4
- Hemorrhage: chest: 3

15 Patients (18% of Deaths)

- Hemorrhage-multiple: 1

Mechanism

- Fall 1
- MCC 2
- Pedestrian Struck 2
- Stab/GSW 4
- MVC 6

*11: Possibly preventable/reversible
Trauma Deaths: Where & When
2013 UMass Medical Center Experience

107 deaths
- Brain: 62 (58%)
- Pulmonary: 19
- Bleeding (6%):
  - Chest: 5
  - Abdomen: 1

23 “immediate”

Trauma Deaths
- Pre-Hospital: 7
- Brain: 6
- OR: 2
- DOA: 15
Issues

Triage

Airway Control

Control of Hemorrhage

Initial Resuscitation
  How much
  With what
Control of Hemorrhage
Non Compressible Torso Hemorrhage (NCTH)

- Large intracavity axial vessels
- Solid organ injuries
  - liver
  - spleen
  - kidney
- Pulmonary parenchymal injuries
- Cardiac wounds
- Complex pelvic fractures
50 patients underwent EDT for abdominal exsanguination

- 98% penetrating trauma
- 16% survival to discharge
- 6 had vascular injuries
- all required MTP
Self-expanding foam improves survival following a lethal, exsanguinating iliac artery injury

Adam Rago, MS, Michael J. Duggan, DVM, John Marini, John Beagle, George Velmahos, MD, PhD, Marc A. De Moya, MD, Upma Sharma, PhD, John Hwabejire, MD, and David Richard King, MD, Boston, Massachusetts

Journal of Trauma ACS; July, 2014; pp73-77.

- Closed abdomen: swine animal model
- Self-expanding polyurethane foam
- Injury: transected iliac artery

Results:
- significant survival advantage:
  135-175 mins vs 32 mins in controls
- Foam easily removed from organs
- Transient increase in IAP

Assumes: free “open” peritoneal cavity
Non Compressible Torso Hemorrhage (NCTH): Balloon Occlusion of the Abdominal Aorta

Used as early as the Korean War

Recent resurgence in interest with better devices and its use in rupture aortic aneurysms

Less physiologic burden in gaining proximal control of the aorta:
- occlusion without entering body cavity
- same improvements in mean aortic pressure as aortic x-clamping but lower lactate, base excess, and pH after intervention

Abdominal occlusive devices techniques:
- Balloon occlusion: REBOA
A clinical series of resuscitative endovascular balloon occlusion of the aorta for hemorrhage control and resuscitation

Megan L. Brenner, MD, Laura J. Moore, MD, Joseph J. DuBose, MD, George H. Tyson, MD, Michelle K. McNutt, MD, Rondel P. Albarado, MD, John B. Holcomb, MD, Thomas M. Scalea, MD, and Todd E. Rasmussen, MD

*Journal of Trauma ACS*; 2014 75(3); pp506-511

A novel fluoroscopy-free, resuscitative endovascular aortic balloon occlusion system in a model of hemorrhagic shock

Daniel J. Scott, MD, Jonathan L. Eliaason, MD, Carole Villamaría, MD, Jonathan J. Morrison, MRCS, Robert Houston, IV, MD, Jerry R. Spencer, BS, and Todd E. Rasmussen, MD, Ann Arbor, Michigan

*Journal of Trauma ACS*; 2013 75; pp122-128

Physiologic tolerance of descending thoracic aortic balloon occlusion in a swine model of hemorrhagic shock

Nickolay P. Markov, MD, Thomas J. Percival, MD, Jonathan J. Morrison, MRCS, Jonathan J. Morrison, MRCS, Jonathan J. Morrison, MRCS, James D. Ross, PhD, Daniel J. Scott, MD, Jerry R. Spencer, BS, and Todd E. Rasmussen, MD, San Antonio, TX, Birmingham, UK, and Bethesda, MD

*Surgery*; June 2013; 153(6)pp848-856

- 6 clinical cases: REBOA using fluoro imaging
- REBOA used to occlude thoracic or abdominal aorta
- 2 deaths: cerebral

- Fluroscopy free REBOA in swine model
- REBOA positioned correctly 88% of insertions
- Animals tolerated 90 mins of aortic occlusion

- Physiologic tolerance to 30 and 90 min Zone I occlusions in a swine model: NON LETHAL HEMORRHAGE

**Cerebral Oxygenation**

- REBOA
- Shock
- \( p < 0.05 \)
REBOA: Occluding the aorta - Organs at risk

**Assumptions**
- perfusing rhythm
- secured airway
- massive transfusion
- non-exsanguinated hemorrhage

**Thoracic aorta control**: visceral organs not perfused, brain, heart protected

**Abdominal aorta control**: visceral organs not perfused, kidneys, heart, lungs, brain protected

*Journal of Trauma; 2011; 71(6); pp1869-1872*
“Hybrid Room” Benefits

- Proximal/distal control of non compressible hemorrhage
- Endovascular repair of stentable lesions without exposing area of injury
- For “unstentable” lesions – Used before open repair to gain proximal/distal control, often in areas very difficult to expose.
  - Zone I, III neck injuries
  - Truncal/extremity junctions
Order of Susceptibility to Warm Ischemia

- Brain
- Heart
- Liver
- GI tract

Brain and Heart are Perfused

No more than 30 minutes of warm ischemia for the Visceral organs

Organ Preservation
Exsanguinated hemorrhage

- Non-perfusing rhythm, PEA, complete arrest
- Proximal aortic wound
- Cardiac wound
- Pulmonary hilar injury

Repair before Reperfusion

- Aortic occlusion, restoring cardiac function only results in further exsanguination
- Identification and repair of the injury must be done before restoring circulation
Exsanguinated Hemorrhage Research Opportunities

Preserving at-risk Organs
- Non-perfused transport
- Repair
- Resuscitation

Access and Triage
- TXA
- PCC
- Lyophilized FFP
- PRBC

Cold, Oxygenated Perfusates

Portable Pump

Rewarming
- When?
- How fast?

Reperfuising: with what?

Reanimation: protecting the cerebral cortex
Noncompressible Hemorrhage
Civilian Unmet Needs

Process

- Identification of the patient at risk: EMS
- Maintenance of infrequently used skills
- Regionalization of “reanimation centers of excellence”

Devices

- Endovascular catheters
- Cavitary access: internal compression
- Maintenance fluids: pre-hospital
- Reliable vascular access
  - IO
  - Arterial
  - Venous
- Portable battery powered pumps
And this will all lead to....
Allow hypotension, hypoperfusion
- Inject perfusates?
- Correct coagulopathy?
- Cool?
- Transport to “Regional Reanimation Center”? 

Stop on-going hemorrhage
- External: pressure, suture, tourniquet
- Internal: cavitary compression, REBOA
- Identify, repair and then resuscitate

Preserve viability post re-perfusion:
- Cool/rewarm
- Cellular preservatives
Questions ??