Surgical Lessons Learned During the War on Terror

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Conflict of interest disclosures: None

The opinions expressed in this talk are those of the speaker, CAPT Mullins, and do not reflect the opinions or policies of the US Navy or the Department of Defense.

Five lessons learned (relearned?) in the past decade

• Forward Surgical Treatment can save lives.
• Patients w/ exsanguinating hemorrhage benefit from 1 FFP for each unit of red cells.
• Tourniquets are effective, but incur the “life or limb” dilemma.
• Good injury prevention always trumps outstanding surgery.
• “It is only a concussion” is a discredited concept.

THE DILEMMA
Forward Surgical Hospitals mean shorter time intervals from injury to OR.
Surgery delayed until the wounded is evacuated to a fully capable hospital
Invasion of Iraq, 2003
US Navy Forward Resuscitative Surgical System (FRSS) supports USMC Regimental Combat teams

FRSS Equipment and Supplies
- General Surgery: 3 major, 3 minor instrument sets
- Orthopedics: drills and external fixators
- Neurosurgery: Burr holes sets
- Portable Ventilators
- 80 units of type O PRBCs in refrigerator
- 2 portable oxygen generators
- No x-rays: Portable ultrasound
- Blood gas analyzer: – pH, PaO2, PaCO2, BE, HCT, Na⁺, Ca²⁺, K⁺

Capt HR Bohman performing laparotomy
March 2003 in FRSS

Summer, 2003
The War in Iraq transitions to a Counter-insurgency war
FRSS located with USMC Headquarters, Babylon, Iraq
2003: 8 person Forward Resuscitative Team
2 Surgeons, 1 Anesthesiologist, 1 nurse, 3 corpsmen
and one USMC driver.

Wound has been covered with “Quik-Clot”

FRSS Surgery was “clean” not sterile

2012: Forward Surgical Team 4509: Role IIE.
Forward Operating Base Lagman
Qalat, Afghanistan.

Rehydrating the surgeon post op

Trauma resuscitation bay at
FST FOB Lagman.
Two OR tables,
Three post-op recovery beds
All patients evacuated within 24 hours.
It’s twins.
Bill Mauldin
Stars and Stripes, 1944

What is the obligation of forward surgical teams to treat civilians?

Medical Rules of Eligibility
Established by Commander, Medical Task Force, Afghanistan

Summary:
Forward Surgical capability

• Time from injury to OR is less, but greater number of moribund patients arrive alive
• Austere resources, resupply delayed and surgical team must be careful using resources
• “General Surgeon” needed; full range of injuries but no specialists.
• What are the surgical team’s responsibilities to civilians?

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Clinical Practice Guideline
Specific instructions on preferred treatments.
The ratio of blood products transfused affects mortality in patients receiving massive transfusions at a combat support hospital.

Borgman et al. J Trauma 2007; 63: 805

“For practical purposes, massive transfusion protocols should utilize a 1:1 ratio of plasma to RBCs for all patients who are hypocoagulable with traumatic injuries.”

<table>
<thead>
<tr>
<th>Ratio</th>
<th>FFP:RBC</th>
<th>BE</th>
<th>ISS</th>
<th>MORTALITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>“Low” (1:8)</td>
<td>-13</td>
<td>18</td>
<td>65%</td>
<td></td>
</tr>
<tr>
<td>“Medium” (1:2.5)</td>
<td>-9</td>
<td>18</td>
<td>34%</td>
<td></td>
</tr>
<tr>
<td>“High” (1:1.4)</td>
<td>-8</td>
<td>18</td>
<td>19%</td>
<td></td>
</tr>
</tbody>
</table>

In a logistic regression model, as the plasma: RBC ratio increased toward 1:1, odds of survival increased. Odds ratio 8.6 (95% CI 2.1-35.2)

Impact of improved combat casualty care on combat wounded undergoing laparotomy and massive transfusion (> 10 units RBC/24 hrs)
Simmons et al. J Trauma 2011; 71: 582.

<table>
<thead>
<tr>
<th>TABLE 5. Cumulative FFP-RBC Ratios</th>
</tr>
</thead>
<tbody>
<tr>
<td>December 2003</td>
</tr>
<tr>
<td>ED ratio</td>
</tr>
<tr>
<td>OR ratio</td>
</tr>
<tr>
<td>Total ratio</td>
</tr>
</tbody>
</table>

Data were presented as mean ± SD.

Total Red cells: 23 +/- 12 | 21 +/- 12
Mortality rate: 47% | 20%

The data shows higher FFP to RBC ratio is associated with improved survival.

Conclusion (Hypothesis)
In patients who require a massive transfusion, “One to One to One” —one unit of FFP for each red cell unit and a platelet-apheresis pack for every six red cell units reduces blood loss and improves survival.

Is fresh whole blood optimal?
In civilian blood bank practice, a unit of blood is separated into components FFP, Packed Cells, Platelet packs.

Additives; lasts 42 days

In Iraq/Afghanistan 6000 units of warm fresh whole blood have been transfused. After donor screening...

Wounded military personnel given warm fresh whole blood had a 13% improved survival.

US Military Patients treated in Iraq and Afghanistan 2004-2007 who met inclusion criteria

<table>
<thead>
<tr>
<th>Fresh whole blood n=100</th>
<th>Conventional blood Transfusion n = 254</th>
</tr>
</thead>
<tbody>
<tr>
<td>ED temperature</td>
<td>97.6</td>
</tr>
<tr>
<td>Heart rate</td>
<td>112</td>
</tr>
<tr>
<td>Systolic Blood pressure</td>
<td>110</td>
</tr>
<tr>
<td>Hemoglobin g/dL</td>
<td>11.6</td>
</tr>
<tr>
<td>Base deficit mEq/dL</td>
<td>6</td>
</tr>
<tr>
<td>ISS</td>
<td>18</td>
</tr>
<tr>
<td>INR</td>
<td>1.4</td>
</tr>
<tr>
<td></td>
<td>98.5</td>
</tr>
<tr>
<td></td>
<td>115</td>
</tr>
<tr>
<td></td>
<td>109</td>
</tr>
<tr>
<td></td>
<td>11.8</td>
</tr>
<tr>
<td></td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>1.4</td>
</tr>
</tbody>
</table>

Similar characteristics

The two groups got the same volume of red cells.

Walking blood bank at FST Lagman. Military personnel volunteer to be blood donors and were screened in advance. Blood collected was typed and then immediately given to the patient.
Mechanism of injury affects acute coagulopathy of trauma in combat casualties.

*J Trauma* 2011; S71: S74. Simmons et al.

**Acute Coagulopathy of Trauma**

A coagulation disorder that occurs in patients “early”. Because of the “magnitude of tissue injury” and/or minor genetic variations in coagulation function.

<table>
<thead>
<tr>
<th>GSW (N = 78)</th>
<th>Explosion (N = 372)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hgb (g/dL)</td>
<td>117 ± 25</td>
<td>113 ± 23</td>
</tr>
<tr>
<td>Hct (L/L)</td>
<td>33 ± 62</td>
<td>42 ± 72</td>
</tr>
<tr>
<td>INR</td>
<td>1.3 ± 0.5</td>
<td>1.4 ± 1.0</td>
</tr>
<tr>
<td>Mortality</td>
<td>24%</td>
<td>21%</td>
</tr>
</tbody>
</table>

Summary:

Optimal management of massive transfusion

- A patient in shock following combat injury needs rapid infusion of red cells and FFP to restore blood volume.
- Prompt surgery to control hemorrhage must accompany resuscitation.
- A formula based 1 to 1 to 1 transfusion ratios is an ideal goal, that may not be practical.
- Civilian medical centers need to develop a program for fresh whole blood transfusion.

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Combat Action Tourniquet.

Adjuncts for hemostasis:

2003-2007  
Topical Agents  

2006-2012  
Tourniquets
In the resuscitation area, replace CAT with pneumatic tourniquets

Survival With Emergency Tourniquet Use to Stop Bleeding in Major Limb Trauma

Kragh, JF et. Al.

In the resuscitation area, replace CAT with pneumatic tourniquets

Survival With Emergency Tourniquet Use  

- All patients who had a tourniquet applied for an extremity injury.
- 428 tourniquets were applied to 309 extremities in 232 patients.
- Pre ED tourniquets: 194 patients:
  - 11% mortality
  - Time from injury until tourniquet: Median 10 minutes
- ED tourniquets: 34 patients.
  - 24% mortality

Survival With Emergency Tourniquet Use

Explosive devices unique to the war zone were the most common cause of extremity injury


TABLE 3. Number of Injuries by Type in Cases With Tourniquet Use for 309 Limbs in 252 Patients

<table>
<thead>
<tr>
<th>Types of Injuries</th>
<th>Number of Limbs With the Indication*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traumatic amputations</td>
<td>97</td>
</tr>
<tr>
<td>Vascular injuries</td>
<td>85</td>
</tr>
<tr>
<td>Open fractures</td>
<td>81</td>
</tr>
<tr>
<td>Soft tissue injuries</td>
<td>45</td>
</tr>
<tr>
<td>Crush injuries</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>309</td>
</tr>
</tbody>
</table>

*The most severe injury for each limb was listed as the indication. The amputations are traumatic injuries in this table and not surgeries or amputations.

Five patients with extremity bleeding + no tourniquet compared to 13 matched patients with extremity bleeding + tourniquet.


19M patients with tourniquet applied before hospital arrival

Compared to 38 patients with tourniquet applied in hospital ED.
Among 309 tourniquets applied in the ED 28% were improperly tightened. Kragh et al / Trauma. 2008;64(suppl):S38–S49.

“Total” ineffectiveness
Tourniquet in place and patient was bleeding
• N = 44
• Tourniquet “loose”
• 21 had fasciotomy
• 15 amputations
• 3 muscle necrosis/clot
• 4 deaths

“Partial” ineffectiveness
Persistent pulse distal to tourniquet
• N = 43
• “Venous” tourniquet
• 19 had fasciotomy
• 3 amputations
• 1 muscle necrosis/clot
• 1 death

Promptly remove the CAT and if bleeding occurs, replace with pneumatic tourniquets.

Civilian wounds which had stopped bleeding. Would application of a tourniquet be meddlesome?

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In 2003 Humvee provided minimal protection from small arms fire or explosions.


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Dec 8, 2004, Camp Buering, Kuwait
Secretary of Defense Donald Rumsfeld was asked why soldiers going into Iraq had to scrounge through local landfills for pieces of scrap metal to bolt to their vehicles.

The SOD responded, "As you know, you go to war with the Army you have. They're not the Army you might want or wish to have at a later time."

2007 An up-Armored HUMVEE could stop small arms but not IED's

MRAP
MINE RESISTANT AMBUSH PROTECTED VEHICLES
Appeared in Iraq in 2007. Admiral Michael Mullen, Chair of the Joint Chiefs of Staff commented MRAPs have “taken hits, many, many hits that would have killed soldiers and Marines in up-armed Humvees.”

IED DAMAGE TO AN AMBULANCE

CDC “Category A” Bioterrorism threats
Easily disseminated, high mortality rates, lead to social disruption and public health “special action” would be required.

Agents: Anthrax, Botulism, Plague, Smallpox, Viral hemorrhagic fevers (e.g. Ebola)

Smallpox Vaccination
The Scourge of Chemical weapons
Organophosphates
Lethal nerve agents:
• Tabun
• Sarin
• Soman
• VX

2003 during invasion of Iraq, Marines wear part of Mission Oriented Protective Posture (MOPP) gear.
Chemical Weapons of Mass Destruction not found.

Investors Business Daily Posted 07/19/2012
Syria’s Chemical Weapons Came From Saddam’s Iraq
“As the regime of Bashar Assad disintegrates, the security of his chemical arsenal is in jeopardy. The No. 2 General in Saddam Hussein's Air Force says they were the WMDs we didn't find in Iraq.”

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Mild traumatic brain injury in U.S. soldiers returning from Iraq
Hoge CW. McGurk D. Thomas JL. Cox AL. Engel CC. Castro CA.
Mild traumatic brain injury is not innocuous

2714 soldiers completed a questionnaire.
• 3-4 months after returning from a one year deployment with “high levels of combat”
• It asked if the soldier was injured.
• It determined among injured soldiers those who had mild traumatic brain injury
  — Loss of consciousness = “knocked out”
  — Altered Mental status =
    • “being dazed, confused, seeing stars”
    • “not remembering the injury event”

Diagnosis of Post Traumatic Stress Disorder (PTSD) made using validated questionnaire.
• A17-item National Center for PTSD Checklist.
  — Investigators selected a score > 50 as the threshold for diagnosis of PTSD.
• To make the diagnosis of “major depression” a 9 item depression assessment module was used.
• Combat intensity was measured with a 17 question scale.
Characteristics of the soldiers
Investigators excluded patients who had a diagnosis of a “significant” traumatic brain injury

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>% Explosion</th>
<th>PTSD%</th>
</tr>
</thead>
<tbody>
<tr>
<td>No injury</td>
<td>N = 1706</td>
<td>N/A</td>
</tr>
<tr>
<td>TBI Injury with</td>
<td></td>
<td></td>
</tr>
<tr>
<td>– Loss of Consciousness</td>
<td>N = 124</td>
<td>79%</td>
</tr>
<tr>
<td>TBI Injury with</td>
<td></td>
<td></td>
</tr>
<tr>
<td>– Altered Mental Status</td>
<td>N = 260</td>
<td>73%</td>
</tr>
<tr>
<td>Other injury</td>
<td>N = 435</td>
<td>23.2%</td>
</tr>
</tbody>
</table>

In logistic regression models, PTSD correlated with “only loss of consciousness and exposure to a high intensity combat”

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Odds of PTSD</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mild Traumatic Brain Injury</td>
<td>2.98</td>
<td>1.7-5.24</td>
</tr>
<tr>
<td>Other “non TBI” Injuries</td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td>Quartile of combat intensity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4th Highest intensity</td>
<td>11.58</td>
<td>2.99 – 44.83</td>
</tr>
<tr>
<td>3rd</td>
<td>5.92</td>
<td>1.51 – 23.31</td>
</tr>
<tr>
<td>2nd</td>
<td>5.09</td>
<td>1.36 – 19.11</td>
</tr>
<tr>
<td>1st Lowest</td>
<td>1.0</td>
<td></td>
</tr>
</tbody>
</table>

Conclusion:
15% of soldiers sustained a “mild” traumatic brain injury. PTSD can be disabling and lead to disability for months or years.

PTSD is linked to physical health problems

Morphine use after Combat Injury in Iraq and Post-Traumatic Stress Disorder.
Holbrook TL, Galarneau MR, Dye JL, Quinn K, Dougherty AL.

Morphine given during initial trauma care may reduce late onset PTSD

A traumatic event causes an intense stimulation of the amygdala. “Memory consolidation” occurs.

PTSD = reflex in the amygdala, is felt as an intense “fight or flight” reaction

Schumann, CM et al J Neuroscience 2004; 4: 639

696 military personnel wounded in Iraq from Jan 2004 to Dec 2006.

- Diagnosis of PTSD if at any time in two years follow up, based upon explicit diagnostic criteria
- Treatment during the first 24 hours at a “forward medical treatment facility”

<table>
<thead>
<tr>
<th>Morphine given during initial trauma care</th>
<th>Why were casualties not given pain meds?</th>
</tr>
</thead>
<tbody>
<tr>
<td>492 given morphine</td>
<td>204 did not receive morphine</td>
</tr>
<tr>
<td>30% developed PTSD</td>
<td>47% developed PTSD</td>
</tr>
</tbody>
</table>
Conclusion:

Early use of morphine in injured patients reduced the patients’ risk for PTSD.

<table>
<thead>
<tr>
<th></th>
<th>Un-adjusted odds of PTSD</th>
<th>Adjusted odds of PTSD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Morphine not given</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Morphine given</td>
<td>0.47 (95% CI 0.34-0.66)</td>
<td>0.48 (95% CI 0.34-0.68)</td>
</tr>
</tbody>
</table>

Does the ICU experience include the elements of an “extraordinary stressful life threatening event”?

PTSD after exposure to ICU

- PTSD is not a yes or no phenomenon; rather PTSD is a pathological condition with a range of severity
- Twigg et al (2007): 45% had PTSD at 3 months.
- Jones et al (2007): PTSD from 3% to 15% in 5 ICUs
- Granja et al (2008): 18% had PTSD at 6 months.
- Wallen et al (2008): 5% to 31% in 15 published studies
- Samuelson et al (2007): 8.4% who had mech ventilation had PTSD

Minor TBI has serious consequences

- To identify the consequences will require long term follow-up, and proper testing.
- Failure to achieve adequate pain control may be causing permanent changes in brain function.
- Early interventions are needed, avoidance of repeated minor TBI critical.

Hippocrates: 400 BC

“He who wishes to be a surgeon should go to war.”

In times of war the military needs surgeons.