Death on the Battlefield
Implications for Prevention, Training, and Medical Care

US Army Institute of Surgical Research
and
Armed Forces Medical Examiner Service

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Disclaimer

The opinions or assertions contained herein are the private views of the author and are not to be construed as official or as reflecting the views of the Department of the Army or the Department of Defense.
JTTS Vision

That every soldier, marine, sailor, or airman injured on the battlefield or in the theater of operations has the optimal chance for survival and maximal potential for functional recovery.
Data Sources

Joint Theater Trauma Registry (JTTR)

- Largest combat Injury database in existence
- All services injury data derived from level IIb, III, IV and V medical charts
  - Scoring of Injuries
  - Diagnosis and Procedures
  - Outcomes
- 60,000 US military injury patient records

Armed Forces Medical Examiner System (AFMES)

- Maintaining the DoD Medical Mortality Registry. The registry component, which has the broader mission of analyzing all active duty deaths for trends and preventable or modifiable risk factors.
Battle Injuries by Body Region

- **Upper Extremities**: 22%
  - Shoulder/Upper Arm: 6%
  - Forearm/Elbow: 6%
  - Wrist/Hand/Fingers: 7%
  - Other: 3%

- **Spine/Back**: 3%
  - 3%

- **Torso**: 15%
  - Chest: 5%
  - Abdomen: 6%
  - Pelvis/ Urogenital: 3%
  - Trunk/Back/Buttock: 1%

- **Lower Extremities**: 31%
  - Hip/Upper Leg/Thigh: 5%
  - Knee/Lower Leg/Ankle: 9%
  - Foot/Toes: 5%
  - Other: 12%

- **Head/Neck**: 27%
  - Face: 7%
  - Eye: 3%
  - Head/Neck: 2%
  - Head/Neck Unspec: 3%

- **Brain Injury (TBI)**: 12%

**Source:** JTTR September 2001 – September 2011
Dominant Mechanism of Injury

- 39% Penetrating
- 67.6% Burns
- 2.9% Blunt
Cause of Injury

*Includes both battle and non-battle injury

- IED: 229
- Bullet/GSW: 177
- Other: 54
- Mortar: 53
- MVC: 25
- Haye: 10
- Gun: 8
- Hand grenade: 1
- Fall: 1
- Machinery: 4
- Helo crash: 1
- RPG: 1
- Knife: 1
- Mine: 1

2/27/2014 Right Patient, Right Care, Right Place, Right Time
Combat Casualty Care Statistics

- \( \%\text{KIA} = \frac{\text{Deaths before MTF}}{\text{KIA} + (\text{WIA} - \text{RTD})} \times 100 \)
- \( \%\text{DOW} = \frac{\text{Died after reaching MTF}}{\text{WIA} - \text{RTD}} \times 100 \)
- \( \text{CFR} = \frac{\text{KIA} + \text{DOW}}{\text{KIA} + \text{WIA}} \times 100 \)
United States Army Institute of Surgical Research

U.S. Combat Deaths (DOW+KIA) sustained during OIF, November 2003 - September 2010 by month

Nov 2003 - Sept 2010
Total KIA: 2,486
Total DOW: 768
Total Deaths: 3,254

Produced by the Joint Theater Trauma Registry
Data Source: JTTR v.3 data extract supplemented by data provided by DMDC & US Pentagon
OIF Cumulative Rolling Monthly Averages: %KIA, %DOW, CFR and Avg mISS
November 2003 - September 2010

Month / Year

Cum KIA %
Cum DOW %
Cum CFR%
Cum Avg mISS

Produced by the Joint Theater Trauma Registry
Data Source: JTTR v.3 data extract supplemented by data provided by DMDC Statistical Analysis Division & US Pentagon OSD
U.S. Combat Deaths Sustained during OEF

U.S. Combat Deaths (DOW+KIA) sustained during OEF, November 2003 - March 2012 by month

Nov 2003 - Mar 2012
Total KIA: 1,107
Total DOW: 361
Total Deaths: 1,468

Produced by the Joint Theater Trauma Registry
Data Source: JTTR v.3 data extract supplemented by data provided by DMDC & US Pentagon
OEF Cumulative Rolling Monthly Averages: %KIA, %DOW, CFR and Avg mISS
Nov 2003 - Mar 2012

Month / Year

Produced by the Joint Theater Trauma Registry
Data Source: JTTR v.3 data extract supplemented by data provided by DMDC Statistical Analysis Division & US Pentagon OSD
Breakdown between WWII, Vietnam, and Iraq/Afghanistan Troops.

**How are we doing? Why?**

<table>
<thead>
<tr>
<th></th>
<th>WWII</th>
<th>Vietnam</th>
<th>Iraq/Afghanistan</th>
</tr>
</thead>
<tbody>
<tr>
<td>% KIA</td>
<td>25.3a</td>
<td>18.6b</td>
<td>12.5c</td>
</tr>
<tr>
<td>% DOW</td>
<td>3.5a</td>
<td>3.0b</td>
<td>4.1c</td>
</tr>
<tr>
<td>CFR</td>
<td>19.1a</td>
<td>16.1b</td>
<td>10.1c</td>
</tr>
</tbody>
</table>

\( a, b, c < 0.001 \)

*Right Patient, Right Place, Right Time, Right Care*
OEF: 7 October 2001—31 December 2010
OIF: 19 March 2003—31 December 2010

Battlefield Mortality Mechanism and Causation
Empiric Probability Combat Death

Bellamy, J Trauma, 1984
Mortality Penetrating Trauma

- Instantaneous Death
  - Hemorrhage
  - Airway obstruction
  - Self aid
  - Buddy aid
  - EMT-B
- Breathing complications
- Shock
- Infections

- PPE and good tactics
- ALS level skills
- Surgery interventions
- And Antibiotics

Time:
- 6min
- 1hr
- 6hr
- 24hr
- 72hr
How People Die in Ground Combat

- 31% KIA - CNS Injury
- 1% KIA - Airway Obstruction
- 7% KIA - Blast/Mutilating Trauma
- 10% KIA - Surgically Correctable Torso Injury
- 9% KIA - Exanguination From Extremity Wounds
- 25% KIA - Surgically Uncorrectable Torso Trauma
- 12% DOW - Largely Infections & Complications Of Shock
- 5% KIA - Tension Pneumothorax

How People Die In Ground Combat (From COL Ron Bellamy)
Where can we save the most lives?

Potentially Survivable Hemorrhagic Deaths on the Battlefield

Of PS deaths, 79% secondary to hemorrhage

- Extremity: 31%
- Torso: 48%
- Axilla/Groin: 21%

Nearly 50% of deaths not amenable to field control
# Battlefield Killers

## Table 4 Causes of Death Among Potentially Survivable Casualties

<table>
<thead>
<tr>
<th>Cause of Death*</th>
<th>Group 1 (n = 93) (%) Total of PS</th>
<th>Group 2 (n = 139) (%) Total of PS</th>
</tr>
</thead>
<tbody>
<tr>
<td>CNS</td>
<td>12 (13)</td>
<td>8 (6)</td>
</tr>
<tr>
<td>Head</td>
<td>11 (12)</td>
<td>6 (4) (p &lt; 0.04)</td>
</tr>
<tr>
<td>Neck</td>
<td>1 (1)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Spinal cord</td>
<td>1 (1)</td>
<td>3 (2)</td>
</tr>
<tr>
<td>Hemorrhage</td>
<td>81 (87)</td>
<td>116 (83)</td>
</tr>
<tr>
<td>Tourniquetable (ext)</td>
<td>31 (33)</td>
<td>46 (33)</td>
</tr>
<tr>
<td>Noncompressible (torso)</td>
<td>47 (51)</td>
<td>68 (49)</td>
</tr>
<tr>
<td>Nontourniquetable (ax/neck/groin)</td>
<td>19 (20)</td>
<td>29 (21)</td>
</tr>
<tr>
<td>Airway</td>
<td>14 (15)</td>
<td>14 (10)</td>
</tr>
<tr>
<td>Sepsis/MSOF</td>
<td>2 (2)</td>
<td>9 (6)</td>
</tr>
<tr>
<td><strong>Total causes of death identified</strong></td>
<td>219</td>
<td>299</td>
</tr>
</tbody>
</table>

* Casualties could have 1 or more cause of death. MSOF indicates multisystem organ failure.
Timing of Trauma Death

- Acute (<1 hour): 45%
- Early (1-4 hrs): 34% (Civilian), 17% (Baghdad)
- Late (>7 days): 20% (Civilian), 3% (Baghdad)

Martin et al., J Trauma 2009
Combat Hospital Killers

- Hemorrhage: 62%
- Brain
- Hypoxia
- MODS

Martin et al., J Trauma 2009
Died of Wounds Analysis
DOW Analysis

- Review died of wounds (DOW) deaths n=558

- Variables
  - Demographics
  - Mechanism and cause
  - Injury severity

- Expert panel trauma surgeons, emergency physician, neurosurgeon, and forensic pathologist graded deaths as non survivable or potentially survivable.

- Goal: Identify areas for improved training, medical care, material, research and development
DOW Analysis

- DOW rate 4.6%
- NS in 271 (48.6%) and PS in 287 (51.4%)
- 51% presented in extremis with CPR on admission
DOW ISS

- ISS 0 - 15: 14%
- ISS 16-25: 27%
- ISS 26-55: 51%
- ISS 55+: 8%
DOW Cause

- Explosion: 72%
- GSW: 25%
- MVC: 2%
- Helo Crash: 1%
DOW
Non-Survivable Etiology

- 83%
- 16%
- 1%

Traumatic Brain Injury: 83%
Hemorrhage: 16%
Other: 1%

Eastridge et al, J Trauma 2011
DOW
Potentially Survivable Etiology

- Hemorrhage: 80%
- Traumatic Brain Injury: 9%
- Multiple Organ Failure: 8%
- Other (Airway, PTX, ...): 3%

Eastridge et al, J Trauma 2011
DOW (Potentially Survivable) Hemorrhage Focus

- Truncal: 48%
- Extremity: 31%
- Junctional: 21%

Eastridge et al, J Trauma 2011
Killed in Action Analysis
KIA Analysis

- Review battlefield deaths (n=4,596)

- Variables
  - Demographics
  - Mechanism and cause
  - Injury severity

- Expert panel trauma surgeons, emergency physician, neurosurgeon, and forensic pathologist graded deaths as non-survivable or potentially survivable.

- Goal: Identify areas for improved training, medical care, material, research and development
KIA Analysis

- Nonsurvivable
  - Dismemberment
  - Traumatic brain injury
  - Cervical cord transection (above C3)
  - Airway transection within thorax
  - Cardiac injury (>1/2”), thoracic aorta injury, pulmonary artery
  - Hepatic avulsion
  - Junctional lower extremity amputations with open pelvis with soft tissue loss
KIA Analysis

- Potentially survivable
  - All other injuries
Where Battlefield Casualties Die n=4,596
Putting it in Perspective

DOW

KIA
Distribution of Battlefield Death
n=4,596

- Instantaneous: 1,391
- Acute: 2,699
- DOW: 506
Battlefield Pre-MTF Death Analysis
n=4,090 (DOW excluded)
Potentially Survivable Pre-MTF Death Analysis (n=1,075)

Increased Expectation of Survival

- < 25: 323
- 26 - 50: 621
- > 50: 131

Injury Severity Score
Battlefield Pre-MTF Mortality Cause

n=4,090
Battlefield Instantaneous Lethality
n=1,391
Battlefield Acute Lethality
Non Survivable
(n=1,624)
Battlefield Acute Lethality
Potentially Survivable
n=1,075
Hemorrhage Focus
(n=984)

Lethal Hemorrhage Focus

- Truncal: 675
- Junctional: 170
- Extremity: 139
Can We Have An Impact?

![Graph showing the impact of TCCC intervention on isolated extremity deaths per year. The graph compares Pre-Tourniquet and Post-Tourniquet scenarios. In the Pre-Tourniquet scenario, there are significantly more isolated extremity deaths per year compared to the Post-Tourniquet scenario, demonstrating the effectiveness of the TCCC intervention.]
Conclusion

• Most battlefield casualties (88.9 %) die on the battlefield
• Majority of battlefield deaths (73.7%) are non-survivable
  – Mitigation strategy: prevention
• Hemorrhage is the major mechanism of death in (91.5 %) of PS combat injuries.
  – Mitigation strategy: hemorrhage control
    • Tourniquets
    • Junctional hemorrhage control
    • Intracorporeal hemostasis
      – Freeze dried plasma
      – TXA
      – Novel therapeutics
• Extending the survival time window from POI to MTF
Conclusion

- Understanding battlefield mortality is a vital component of the trauma system
  - Trauma system optimization
  - TCCC improvements
  - Data driven research and development focus
  - Command emphasis
  - Training & tactical perspective
    - Kotwal et al, Arch Surg, 2011
  - Equipment and materiel
Questions ?