Vascular Injuries and Battlefield Surgery in Iraq: Experiences from Operation Iraqi Freedom

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Overview
• Background
• Echelons of care and Aero medical Evacuation
• Resources and capabilities
• Balad Vascular Registry
• Vascular injuries – wounding mechanisms/ ballistics, types vascular injuries management/ outcomes

Background
• Active duty USAF, MC
• Balad, AB, Iraq- 332nd EMDG
  – Sep 2008 – Feb 2009

Echelons of Care – Wartime Military Medicine Structure
• Echelon I – first care soldier receives. Self-aid and buddy care in the field
• Echelon II – evacuated to forward surgical teams. Emergency surgical/ resuscitative
• Echelon III – Large, in–theatre hospital. Multiple surgical subspecialists
• Echelon IV – Germany.
• Echelon V – CONUS

In Theater Level 3 Facilities

In-Theatre Aero medical Evacuation
Comparison to Prior Wartime Experience

- Aero medical evacuation times (time to OR)
  - WW II - 12 hours
  - Korea - 10 hours
  - Vietnam - 5 hours
  - Current - 90 min - 2 hours

Evacuation from Theatre - CCAT

Resources & Capabilities

- Outpatient clinics
- ED
- 4 ORs
- 2 CT scanners, plain film, PACS system
- Blood bank, Lab, pharmacy
- Ward, ICU
- General surgery, urology, neurosurgery, vascular, cardiothoracic, ophtho, ENT, OMFS, trauma-critical care (Trauma Czar), orthopaedics, anesthesia
Endovascular Capability in the Field

The Balad Vascular Registry

- 1 Sep 04 → present
- Balad Vascular Registry
- All casualties with vascular injury prospectively entered
- Largest wartime vascular registry since Vietnam conflict

Balad Vascular Registry

- Age & nationality
- Wounding mechanism & vessel(s) injured
- Method of repair; use of shunt
- Associated bony, venous, nerve injury
- Early follow up

Prevalence of Vascular Injury

Of 6,801 major battle injuries, 324 (4.8%) casualties with 347 vascular injuries identified.

Mechanism of Injury

324 Casualties with Vascular Injury

Improvised Explosive Device

Weapon Ballistics

- Japanese rifle WWII
  - 2200 fps
- German rifle WWII
  - 2600 fps
- US General Purpose Bomb
  - 1870 fps (100ft)
  - 3,110 fragments
- US Grenade
  - 2900 fps (2000 fps/20ft)
  - 254 fragments
- US HE round
  - 3,000-7000 fps (2500/20ft)

IMPACT VELOCITY MOST IMPORTANT
50 Caliber-grazing wound

Distribution of Major Vascular Injuries (N=347)

- 243 casualties (70%)
- 52 casualties (16%)
- 29 casualties (9%)

Mechanisms of Injury
Methods of Arterial Repair (n=301)

Distribution of Upper Extremity Arterial Injury (n=76)

11 (14.5%)

42 (55%)

23 (30%)
Results

Distribution of Lower Extremity Arterial Injury (n=158)

- **Tibial**
  - 44 (28%)
- **SFA**
  - 53 (34%)
- **CFA/PFA**
  - 21 (13%)
- **Popliteal**
  - 40 (25%)
- **Tibial**
  - 44 (28%)

Femoropopliteal Injuries

- 9,289 casualties
- 513 vascular injuries (5.3% of casualties)
- 142 casualties / 145 femoropopliteal injuries
- 1.53% prevalence of femoropopliteal injury

Femoral Injuries

<table>
<thead>
<tr>
<th>Anatomic Location</th>
<th>Injuries</th>
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<tbody>
<tr>
<td>Artery only (n=43)</td>
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</tr>
<tr>
<td>SFA</td>
<td>37</td>
</tr>
<tr>
<td>CFA</td>
<td>1</td>
</tr>
<tr>
<td>PFA</td>
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<tr>
<td>CFA/SFA/PFA</td>
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<tr>
<td>CFA/SFA</td>
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<tr>
<td>Vein only (n=10)</td>
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<tr>
<td>SFV</td>
<td>9</td>
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<tr>
<td>CFV</td>
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<tr>
<td>Artery and Vein</td>
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<tr>
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<tr>
<td>SFA/SFV</td>
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<tr>
<td>PFA/SFV</td>
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<tr>
<td>SFA/CFA/CFV</td>
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<tr>
<td>PFA/CFA/CFV</td>
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<tr>
<td>CFA/CFV</td>
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</table>

Popliteal Injuries

<table>
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<tr>
<th>Anatomic Location</th>
<th>Injuries</th>
</tr>
</thead>
<tbody>
<tr>
<td>Popliteal artery only</td>
<td>16</td>
</tr>
<tr>
<td>Popliteal vein only</td>
<td>1</td>
</tr>
<tr>
<td>Popliteal artery &amp; vein</td>
<td>28</td>
</tr>
</tbody>
</table>

Mechanism of Injury

- Majority caused by improvised explosive devices (IEDs) - 54.4%
- Others caused by high velocity gunshot wounds (45%) and one rocket propelled grenade (RPG)

Management of Arterial Injuries

- Autogenous vein - 88%
- Primary repair - 6.8%
- Ligation - 5.2%
  - Profunda femoral
  - No popliteal ligations
Venous Injury and Repair

- 86 femoropopliteal venous injuries
- 72% were repaired

Methods of repair
- Autogenous 40.7%
- Primary 31.4%
- Ligation 27.9%

Treatment Adjuncts

- Temporary arterial shunts
  - In-theater transfer to higher echelons of care
  - During bony fixation, venous repair, or saphenectomy
  - Mass casualty
- Routine fasciotomies

Outcomes

- Early limb loss - 10(6.9%)
  - 9 repair failure
  - 1 progressive soft tissue loss
- Early mortality - 5(3.4%)
  - multisystem organ failure
  - sepsis

Comparison to Prior Wartime Experience

- Early limb loss
  - WWII - 53.2% Fem, 72.5% pop
  - Korea - 15.2%
  - Vietnam - 19%
- Early mortality
  - Korea - 13%
  - Vietnam - 1.7%

Overview

- Echelons of care
- Aero medical evacuation
- Resources & capabilities
- Balad Vascular Registry

Overview

- Prevalence of vascular injury
- Wounding mechanism/ballistics
- Types of vascular injuries
- Management of extremity vascular injury & short term outcomes/results