MANGLED EXTREMITY MANAGEMENT

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MANGLED EXTREMITY IN ARMED CONFLICT

- Injuries of the musculoskeletal system are the most common wounds seen in armed conflicts, representing up to 70% of all injuries. In the current war, 70%-80% of these injuries are the result of explosive devices, such as IED, RPG and mortars.
ORTHOPLASTIC APPROACH

- Evaluation, emergency treatment and stabilization
- How we choose which limbs to salvage
- Soft tissue repair, when, what and who?
CHALLENGES AND CONTROVERSIES

- Functional limb salvage
- High incidence of osteomyelitis, due to extensive contamination
- Valid scoring system
- Variable evac. timing
- Incomplete fasciotomy
- Bone healing
- Nerve injury
- Evidence based infection prevention
- Multiple drug resistant organisms
- Procedure timing
- Coverage and closure
- Fixation
- Better prosthetics/robotics
- Shift level of care to the left?
At “Level II”, evaluation must include:
- time of injury, mechanism, energy absorption, fracture configuration,
- systemic injuries, damage to the soft tissue envelope, vascularity, and nerve status. *This information is critical in the decision process for or against limb salvage*
IN THE OR

- Gross debridement and irrigation
- Revascularization if needed (autogenous vein is preferred) extra-anatomic route is occasionally necessary
- Skeletal stabilization (can follow vascular repair, McHenry et al)
- Low threshold for fasciotomy
- Soft tissue preservation
Fasciotomy Indications in a Combat Zone

- >4-6 hour evacuation delay to revascularization
- Combined arterial and venous injuries
- Crush injuries
- High-kinetic energy mechanism
- Vascular repair
- Arterial or venous ligation
- Comatose, CHI or epidural analgesia
- Tense compartments
- Prophylactic
DEBRIDEMENT

With the exception of tendon and nerve, if it does not bleed it is dead. If it is dead, get rid of it. If you cannot get rid of it, think amputation. Serial debridements and washouts are desirable.
Debridement Amputation

When life over limb is the issue or in certain extremity injuries where there is no means of limb salvage
Soft tissue injury: most important component of high energy trauma

Historically open fracture treatment in which soft tissue injury is neglected, ignored or mistreated has resulted in therapeutic disaster. Gustilo and others have shown that severity of soft tissue injury is the most important factor for predicting infection and nonunion.
How have we decided on salvage versus amputation?

- MESS
- MESI
- PSI
- LSI
- NISSA
- HFS-97
<table>
<thead>
<tr>
<th></th>
<th>All Type-III Fractures (N = 312)†</th>
<th>Type-IIIB Fractures (N = 202)†</th>
<th>Type-IIIC Fractures (N = 27)†</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MESS</strong></td>
<td></td>
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</tr>
<tr>
<td>Sensitivity</td>
<td>0.22 (0.12-0.35)</td>
<td>0.08 (0.02-0.22)</td>
<td>0.57 (0.29-0.82)</td>
</tr>
<tr>
<td>Specificity</td>
<td>0.93 (0.90-0.95)</td>
<td>0.94 (0.89-0.97)</td>
<td>0.69 (0.39-0.91)</td>
</tr>
<tr>
<td>Area under curve</td>
<td>0.68 (0.61-0.75)</td>
<td>0.66 (0.57-0.75)</td>
<td>0.62 (0.38-0.85)</td>
</tr>
<tr>
<td><strong>PSI</strong></td>
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</tr>
<tr>
<td>Sensitivity</td>
<td>0.36 (0.24-0.50)</td>
<td>0.33 (0.19-0.51)</td>
<td>0.50 (0.23-0.77)</td>
</tr>
<tr>
<td>Specificity</td>
<td>0.84 (0.79-0.88)</td>
<td>0.85 (0.79-0.90)</td>
<td>0.69 (0.39-0.91)</td>
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<tr>
<td>Area under curve</td>
<td>0.68 (0.61-0.75)</td>
<td>0.68 (0.59-0.77)</td>
<td>0.63 (0.42-0.84)</td>
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<tr>
<td><strong>LSI</strong></td>
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<tr>
<td>Sensitivity</td>
<td>0.29 (0.18-0.43)</td>
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<td>0.86 (0.57-0.98)</td>
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<tr>
<td>Specificity</td>
<td>0.97 (0.94-0.99)</td>
<td>0.98 (0.95-1.00)</td>
<td>0.69 (0.39-0.91)</td>
</tr>
<tr>
<td>Area under curve</td>
<td>0.79 (0.72-0.85)</td>
<td>0.75 (0.67-0.83)</td>
<td>0.80 (0.63-0.97)</td>
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<tr>
<td><strong>NISSSA</strong></td>
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<td></td>
</tr>
<tr>
<td>Sensitivity</td>
<td>0.13 (0.05-0.24)</td>
<td>0.06 (0.02-0.19)</td>
<td>0.36 (0.13-0.65)</td>
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<tr>
<td>Specificity</td>
<td>0.98 (0.96-1.00)</td>
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<td>0.77 (0.46-0.95)</td>
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<tr>
<td>Area under curve</td>
<td>0.66 (0.59-0.74)</td>
<td>0.64 (0.56-0.73)</td>
<td>0.62 (0.38-0.85)</td>
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<tr>
<td><strong>HFS-97</strong></td>
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<tr>
<td>Sensitivity</td>
<td>0.11 (0.04-0.22)</td>
<td>0.06 (0.01-0.19)</td>
<td>0.29 (0.08-0.58)</td>
</tr>
<tr>
<td>Specificity</td>
<td>0.98 (0.96-1.00)</td>
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<tr>
<td>Area under curve</td>
<td>0.71 (0.63-0.78)</td>
<td>0.69 (0.59-0.77)</td>
<td>0.71 (0.48-0.93)</td>
</tr>
</tbody>
</table>

*MESS = Mangled Extremity Severity Score; PSI = Predictive Salvage Index; LSI = Limb Salvage Index; NISSSA = Nerve Injury, Ischemia, Soft-Tissue Injury, Skeletal Injury, Shock, and Age of Patient Score; and HFS-97 = Hannover Fracture Scale (1997 version). †The 95% confidence intervals are in parentheses. †LSI significantly different from MESS, PSI, NISSSA, and HFS-97 (p < 0.05).
These indices are either cumbersome or lack sensitivity. Generally they address: soft tissue injury, nerve and vascular status, systemic injury, +/- shock, energy absorption, etc.
MESS

- Skeletal/Soft tissue injury: low (simple fall) 1, medium (skiing) 2, high (GSW) 3, very high (car bumper at 20 mph) 4
- Ischemia: none 0, decreased pulse 1, thready pulse 2, pulseless 3
- Shock: normal 0, transient 1, prolonged 2
- Age < 30, 0 30-50, 1 > 50, 2
MESS

Recent publication in Military Medicine (172; 7:777, 2007) validates the MESS score in the combat setting where young average age and high-energy mechanism leave ischemic time and shock as the most important factors in dictating whether a MESS is $>$ or $<$ than 7, therefore injury pattern increases our capacity to predict complications.
Indications for Primary Amputation in Lower Extremity Open Fractures*

Absolute:

a. complete disruption of the posterior tibial nerve in an adult
b. crush injury with warm ischemia >6H or nonreparable vascular injury

Relative:

a. life threatening polytrauma (ISS ≥ 20)
b. severe ipsilateral foot trauma
c. prolonged course to provide soft tissue and tibial reconstruction incompatible with personal, sociologic and economic consequences for the patient

*civilian world
TIMING

- ALL MAJOR STUDIES HAVE SHOWN EARLY FLAP CLOSURE WITHIN 7 DAYS LEADS TO LOWEST COMPLICATION RATES
- BOTTOM LINE: IF YOU ARE INVOLVED IN MANGLED EXTREMITY CARE A COMMITMENT MUST BE MADE TO ACHIEVE COVERAGE WITHIN A WEEK WITH HEALTHY VASCULARIZED TISSUE*
- VAC** USE DOES NOT CHANGE THIS DICTUM

*civilian experience
** vacuum assisted closure
Workhorse Free Flap* Zones

*microsurgical transplantation
Issues that can be addressed with tissue engineering

- Missing or injured nerve
- Neuromas in-continuity
- Missing bone, enhanced bone healing
- Wound vascularity
- Delayed wound healing
TISSUE ENGINEERING CONSIDERATIONS

- Bioabsorbable nerve guides supplemented by growth factors
- Bone matrix to replace need for microsurgical transplantation
- Angiogenic factors
- Acellular tissue matrix to enhance wound healing
Clinical Examples
Spare Parts Concept