Management of Wounds in the Trauma Patient

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Emergency Wound Care

- US ED 12.2 million patients/year
- Most frequently performed procedure second to IV insertion
Malpractice Issues and Emergency Wounds

• Wound care – 5-20% of all emergency medicine malpractice claims and 3-11% dollars paid out

• Most common reasons for litigation:
  – Failure to diagnose foreign bodies
  – Wound infections
  – Failure to detect underlying injury

• Standard of care?
  – 92’ board certified ER physicians
  – 38% soak, 67% scrub, 27% irrigate with “other than recommended irrigation”, and 76% never practice DPC
Basic Principles

- Thorough irrigation
- Assess for tendon injury
- X-rays
- Tetanus
- Antibiotics?
- Fixation? Ex-Fix?
- WOUND CARE!
  - Wound vac
  - Primary repair?
  - OR?
Lacerations

• Avg laceration in ER 1-3cm
• 13% lacerations in ER “significantly contaminated”
• 3.5-6.3% of lacerations → infection
• Assess for other soft tissue injury!!
Burns

Superficial (1°) Example: sunburn

Superficial partial thickness (2°)
Blisters, red moist dermis

Deep partial thickness (2°)
Some adnexal structures preserved (hair follicles)

Full thickness (3°)
Dry, leathery tissue

Deep thermal (4°)
Burn depth to bone
Bite Wounds

- 2 mil/yr in US
- 3.6-23% human bite wounds
- Irrigation/debridement

**Recommendations for empiric antibiotic prophylaxis**

<table>
<thead>
<tr>
<th>Bite source</th>
<th>Cause of infection</th>
<th>Primary treatmenta</th>
<th>Alternative treatmenta</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dog</td>
<td><em>Pasteurella sp.</em></td>
<td>Amoxicillin/clavulanate 875/125 mg po bid or 500/125 mg po tid</td>
<td>Clindamycin 300 mg po qid + FQ (adults)</td>
</tr>
<tr>
<td></td>
<td><em>Staphylococcus aureus</em></td>
<td></td>
<td>Clindamycin + TMP-SMX (children)</td>
</tr>
<tr>
<td></td>
<td><em>Bacteroides sp.</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>Fusobacterium</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>Capnocytophaga</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cat</td>
<td><em>Pasteurella sp.</em></td>
<td>Amoxicillin/Clavulanate 875/125 mg po bid or 500/125 mg po tid</td>
<td>Cefuroxime axetil 0.5 gm po q12h or doxycycline 100 mg po bid</td>
</tr>
<tr>
<td></td>
<td><em>Staphylococcus aureus</em></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Puncture Wounds

- Tetanus!!
- Antibiotics
- Imaging
- Retained foreign body?
- Tendon injury?
Open Fractures

- 6 hour window?
- Antibiotics!!!
- Abx duration?
- Antibiotic beads?
- Washout?
- Close or keep open?
- Fixation?
Table 2

Expanded Version of the Gustilo Classification System of Open Fracturesa

<table>
<thead>
<tr>
<th>Feature</th>
<th>I</th>
<th>II</th>
<th>IIIA</th>
<th>IIIB</th>
<th>IIIC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wound size, cm</td>
<td>&lt;1</td>
<td>&gt;1</td>
<td>&gt;1</td>
<td>&gt;1</td>
<td>&gt;1</td>
</tr>
<tr>
<td>Energy</td>
<td>Low</td>
<td>Moderate</td>
<td>High</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Contamination</td>
<td>Minimal</td>
<td>Moderate</td>
<td>Severe</td>
<td>Severe</td>
<td>Severe</td>
</tr>
<tr>
<td>Deep soft tissue damage</td>
<td>Minimal</td>
<td>Moderate</td>
<td>Severe</td>
<td>Severe</td>
<td>Severe</td>
</tr>
<tr>
<td>Fracture comminution</td>
<td>Minimal</td>
<td>Moderate</td>
<td>Severe/segmental fractures</td>
<td>Severe/segmental fractures</td>
<td>Severe/segmental fractures</td>
</tr>
<tr>
<td>Periosteal stripping</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Local coverage</td>
<td>Adequate</td>
<td>Adequate</td>
<td>Adequate</td>
<td>Inadequate</td>
<td>Adequate</td>
</tr>
<tr>
<td>Neurovascular injury</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Infection rate</td>
<td>0%-2%</td>
<td>2%-7%</td>
<td>7%</td>
<td>10%-50%</td>
<td>25%-50%</td>
</tr>
</tbody>
</table>

aData from Gustilo et al,3 Gustilo and Anderson,10 and Gustilo et al.11
Crush Injury

• Watch for compartment syndrome!
• Imaging
• Soft tissue damage
Degloving Injury

- Limb salvage
- Multiple washouts
- Multi-team approach
- WOUND VAC!
Hyperbaric Oxygen Therapy

- Angiogenesis
- Fibroblast growth
- Collagen production
- Improved osteoclast function
- Inhibits α–toxin production in clostridial myonecrosis
- Improves leukocyte killing
- Decreases neutrophil adherence to capillary walls
- Edema reduction
HBO in the Trauma Patient

- Crush injuries
- Open fractures
- Compartment Syndrome
- Thermal burns
- “Acute Traumatic Peripheral Ischemia”
  - Triad of tissue ischemia, hypoxia, and edema
  - Gradient of tissue injury
  - Capacity of injury to become self-perpetuating
Bouachour et al 1996

- Only RCT
- 36 pts with crush injury
  - 18 HBO
  - 18 Placebo
- Gustilo II or III
- Surgical management within 6 hours

<table>
<thead>
<tr>
<th>Groups</th>
<th>HBO (n = 18)</th>
<th>Placebo (n = 18)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complete healing</td>
<td>17</td>
<td>10</td>
<td>0.009</td>
</tr>
<tr>
<td>Tissue necrosis</td>
<td>1</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>New surgical procedures</td>
<td>2 (1 patient)</td>
<td>8 (6 patients)</td>
<td>0.03 (0.04)</td>
</tr>
<tr>
<td>Skin flaps and grafts</td>
<td>1</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Vascular surgery</td>
<td>1</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Amputation</td>
<td>0</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Wound dressings</td>
<td>15.8 (±9.4)</td>
<td>16.3 (±12.1)</td>
<td>0.45</td>
</tr>
<tr>
<td>Time of healing (days)</td>
<td>50.2 (±21.1)</td>
<td>55.8 (±19.9)</td>
<td>0.21</td>
</tr>
</tbody>
</table>

Data are presented as mean ± SD. The p values were obtained using the chi-squared test, the Fisher’s exact test, and the Student’s test.
HBO in the Trauma Patient: What does the Literature Say?

Yamada et al 2014

crush injuries and open fractures Gustilo class IIIA

**Table 4. Comparison of clinical outcomes between the HBO\(_2\) and control groups**

<table>
<thead>
<tr>
<th>Group</th>
<th>HBO(_2) ((n = 16))</th>
<th>Control ((n = 13))</th>
<th>(p)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infection</td>
<td>0 (0%)</td>
<td>6 (46%)</td>
<td>0.003</td>
</tr>
<tr>
<td>Requiring additional surgical debridement procedures</td>
<td>0 (0%)</td>
<td>5 (38%)</td>
<td>0.013</td>
</tr>
<tr>
<td>ICU stay (days)</td>
<td>8.8 ± 5.8</td>
<td>12.3 ± 7.3</td>
<td>N.S</td>
</tr>
<tr>
<td>Hospital stay (days)</td>
<td>49 ± 41</td>
<td>42.6 ± 28.5</td>
<td>N.S</td>
</tr>
</tbody>
</table>

HBO\(_2\): hyperbaric oxygen; ICU: Intensive care unit
<table>
<thead>
<tr>
<th>Author (Ref.)</th>
<th>Study Design/ Data Class</th>
<th>Patient Traits</th>
<th>HBO Protocol</th>
<th>Outcome</th>
<th>Beneficial</th>
</tr>
</thead>
<tbody>
<tr>
<td>Székely (15)</td>
<td>Case series, No control/III</td>
<td>5 cases with severe injury to the limbs including 3 with associated fractures.</td>
<td>2 ATA, Variable duration.</td>
<td>2 died; 3 had primary amputation. A serious complication from HBO is mentioned but not specified.</td>
<td>No</td>
</tr>
<tr>
<td>No author (16)</td>
<td>Case series, No control group/III</td>
<td>21 patients with traumatically amputated limbs/limbs.</td>
<td>2–3 ATA q.d.–b.i.d. for about 1 week.</td>
<td>14 were successfully re-implanted.</td>
<td>Yes</td>
</tr>
<tr>
<td>Monies-Chass (17)</td>
<td>Case series, No control group/III</td>
<td>7 patients with severe vascular trauma and associated fractures to the lower extremities. All treated surgically. All had signs of ischemia postoperatively.</td>
<td>2 h at 2.8 ATA every 4 h postoperatively. Mean 9.5 treatments.</td>
<td>Ischemia disappeared in 6 cases. Dry gangrene of toes that required amputation in one patient. No HBO complications.</td>
<td>Yes</td>
</tr>
<tr>
<td>Shpak (18)</td>
<td>Case series, No controls/III</td>
<td>13 patients with traumatic injuries to lower limbs; 10 had major arterial injury and had associated fractures.</td>
<td>90 min at 2.4 ATA b.i.d. after surgery. Mean 5 treatments.</td>
<td>Complete limb salvage in 8 patients. In 4 patients, ischemia level was lowered distally. 3 patients had BKA. 1 patient had AKA, and 1 showed no improvement. No oxygen toxicity.</td>
<td>Yes</td>
</tr>
<tr>
<td>Strauss (19)</td>
<td>Case series, No controls/III</td>
<td>20 patients with compartment syndrome. First group, 10 patients compartment pressure ranged from 15 to 48 mm Hg. Second group, 10 patients compartment pressure not reported.</td>
<td>First group 90 min at 2 ATA b.i.d.–t.i.d. Mean 12 treatments. Second group had HBO after fasciotomy. Mean 36 treatments.</td>
<td>None of the first group of patients required fasciotomy, and all recovered without sequel. Second group “difficult to quantify objectively the benefits of HBO.”</td>
<td>Yes</td>
</tr>
<tr>
<td>Radonic (20)</td>
<td>Retrospective case series/III</td>
<td>13 patients with crural arteries injury. 10 had associated fractures. All treated surgically in conjunction with HBO.</td>
<td>7–21 sessions of 60–120 min at 2.18 ATA</td>
<td>In HBO patients, outcome (function) was very good 2, good 3, fair 7, and one had BKA. In non-HBO patients, outcome was very good 4, good 3, fair 4, BKA 3 patients. AKA 2 (one had BKA initially).</td>
<td>Yes</td>
</tr>
<tr>
<td>Bouachour (21)</td>
<td>PRCT/I</td>
<td>36 patients with Gustillo type II–III injury. Patients with peripheral arterial occlusive disease were excluded. All patients underwent surgical management within 6 h of injury.</td>
<td>After surgery, 18 patients received HBO 90 min at 2.5 ATA b.i.d. for 6 days, and 18 received placebo.</td>
<td>Complete wound healing without necrosis requiring excision in 17 patients of HBO group vs. 10 of placebo group (P &lt; 0.01). Repetitive procedures in 33% placebo group vs. 6% in HBO group (P &lt; 0.05). There were no complications from HBO.</td>
<td>Yes</td>
</tr>
<tr>
<td>Kivoshige (22)</td>
<td>Small series, No controls/III</td>
<td>6 patients, 10 amputated digits. Treatment replantation and HBO.</td>
<td>HBO 2 ATA 1 h for 5 days.</td>
<td>7 survived.</td>
<td>Yes</td>
</tr>
<tr>
<td>Matos (23)</td>
<td>Case series, No control group/III</td>
<td>23 patients with type III crush injuries; grade IIIA (7), grade IIIB (13), grade IIC (3). All patients except two had exam within 24 h of injury.</td>
<td>2.36 ATA for 90 min b.i.d.–q.d. Average of 12 HBO treatments.</td>
<td>20 had preservation of the threatened limb. The 3 failures underwent transfixing amputation.</td>
<td>Yes</td>
</tr>
</tbody>
</table>
HBO in the Trauma Patient: What does the Literature Say?

Eskes et al Cochrane Review 2010

- HBO for acute surgical and traumatic wounds
- 3 trials met inclusion criteria
- Insufficient data to support or refute effectiveness
Hyperbaric Oxygen in Lower Limb Trauma (HOLLT); protocol for a randomised controlled trial

- Acute open tibial fracture GA Grade III
- Minimal age 18
- Enrollment within 48h of injury
Case Presentation 1: Puncture Injury
Case Presentation 1: Puncture Injury
Case Presentation 1: Puncture Injury
Case Presentation 1: Puncture Injury

Plan
• Tetanus booster given in ED
• Antibiotics given in ED
• Patient taken emergently for removal FB/I&D
• Discharged POD#1 on Clinda/Cipro x 5 days
Case Presentation 2: Traumatic Hematoma

CC: traumatic hematoma left foot
HPI: 53yo female presents to ED with left foot bleeding, swelling, pain. 3 weeks prior hit her foot off wooden bedpost. Patient was in ED 3 times as well as outpatient office over the course of the 3 weeks. Compression dressing/splint applied after negative x-rays, patient told to ice and elevate.

PMH: Hepatitis C, Alcoholic Liver Cirrhosis, Alcohol Dependence (remission for 9 days at time of presentation), thrombocytopenia, coagulopathy
SH: current smoker 1.5 PPD for 20 years, alcohol dependence
### Labs

<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td><strong>WBC</strong></td>
<td>Latest Range: 4.00-10.80 K/uL</td>
<td>4.97</td>
<td>3.74 (L)</td>
<td>4.15</td>
</tr>
<tr>
<td><strong>RBC</strong></td>
<td>Latest Range: 3.85-5.15 M/uL</td>
<td>3.29 (L)</td>
<td>3.06 (L)</td>
<td>2.87 (L)</td>
</tr>
<tr>
<td><strong>HGB</strong></td>
<td>Latest Range: 12.0-15.3 g/dL</td>
<td>11.0 (L)</td>
<td>10.1 (L)</td>
<td>9.4 (L)</td>
</tr>
<tr>
<td><strong>HCT</strong></td>
<td>Latest Range: 36.0-45.2 %</td>
<td>32.0 (L)</td>
<td>29.8 (L)</td>
<td>27.7 (L)</td>
</tr>
<tr>
<td><strong>PLATELET COUNT</strong></td>
<td>Latest Range: 140-400 K/uL</td>
<td>56 (L)</td>
<td>35 (LL)</td>
<td>46 (LL)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td><strong>PT/INR-PT</strong></td>
<td>Latest Range: 11.5-14.6 seconds</td>
<td>22.2 (H)</td>
<td>17.9 (H)</td>
<td>18.8 (H)</td>
</tr>
<tr>
<td><strong>PT/INR-INR</strong></td>
<td>Latest Range: 0.85-1.16</td>
<td>2.01 (H)</td>
<td>1.52 (H)</td>
<td>1.62 (H)</td>
</tr>
</tbody>
</table>
Surgical Plan

- 4U FFP
- Platelets
- Vanc/Zosyn
- ID Consult
- OR for evacuation hematoma/debridement
Hospital Course

• Infectious Disease: Unasyn as inpatient
• Gastroenterology: Trental, will f/u as outpatient for management of cirrhosis, portal HT and hepatitis C
• Hematology:
  • bleeding tendency due to combination of abnormal coags due to liver disease and thrombocytopenia - probably due to ETOH/Hep C/cirrhosis vs ITP
  • F/U Abdominal imaging results for any splenomegaly/ fibrinogen and PTT levels
  • Will give cryoppt if fibrinogen is low preoperatively
  • FFP as needed if PTT/INR is elevated
• Repeat washout/debridement/wound vac
• Discharged with wound vac and home health
F/u in Wound Care Center
2 months following initial I&D
Case Presentation 3: Crush Injury/Compartment Syndrome

CC: Right foot pain/crush injury
HPI: 50yo male presents with right foot pain. He states that he was at work earlier today (works for PennDot) and was operating a road milling machine when both of his feet became stuck under the machine. He was able to get his left foot out from under the machine after a brief period of time; however, his right foot remained under the machine for 45 minutes. The part of the machine that his foot was caught under had a sharp metal portion that was on top of his foot. After his foot was removed form the machine he was brought to the ED immediately.

PMH (+) obesity, HTN, (+) EtOh use
Case Presentation 3: Crush Injury/Compartment Syndrome

- Tetanus booster, Ancef administered in ER
- Emergent fasciotomy
- Monitor for rhabdomyolysis – CPK total q6h
Case Presentation 3: Crush Injury/Compartment Syndrome
Case Presentation 3: Crush Injury/Compartment Syndrome

1 week postop
Case Presentation 3: Crush Injury/Compartment Syndrome

- 1 month postop
- Scheduled for debridement, Integra/wound vac in OR
- fracture healed uneventfully
- wound healed 4 months after initial injury
Case Presentation 4: Motorcycle Accident

CC: degloving injury

HPI: 27yo male presented to Trauma Bay following motorcycle crash. Pt unhelmeted, motorcycle struck by SUV.

He suffered multiple injuries including:
- Left degloving foot wound, left 2\textsuperscript{nd} met midshaft open fx, left 4\textsuperscript{th} and 5\textsuperscript{th} digit open fx.
- Left open midshaft tibial fracture and fibular shaft fracture
- Left closed displaced midshaft femoral fracture
- Right intra-articular comminuted distal femur fracture.

No PMH, former smoker
Case Presentation 5: Degloving Injury

CC: mangled foot
HPI: 33yo female presented to Trauma Bay after being struck by a vehicle. Pt relates that her foot was stuck between the car and the curb.

PMH: Hepatitis C
SH: current smoker, 1PPD, IVDA
Case Presentation: Degloving Injury

Surgical Plan:
- Patient refuses any further amputation
- I&D
- Ex-Fix 1\textsuperscript{st} Ray
- ORIF 4\textsuperscript{th} Metatarsal
- Wound Vac
Repeat Washout/Wound Vac Change in OR
Repeat Washout/Wound Vac Change in OR
Repeat Washout/Wound Vac Change in OR
Repeat Washout/Wound Vac Change in OR
Repeat Washout/Wound Vac Change in OR
Repeat Washout/Wound Vac Change in OR
TMA with Wound Vac Application
TMA with Wound Vac Application
TMA with Wound Vac Application
Conclusions

- Common in emergency medicine
- Basic wound care tenets
- Refer quickly to specialist
  - Multiple team approach!!
- Consider HBO
- Each case unique, no single way to treat
References: