I have NO financial disclosure or conflicts of interest with the presented material in this presentation.
no evidence based data identified to justify modification to this approach in civilian patients.
INITIAL ASSESSMENT

1 L of crystalloid

20 cc/kg < 40 kg

Blood Early (1:1:1 ratio)

10-20 mL/kg of RBC/FFP/Plt

TXA

Airway
AIRWAY

Rapid Sequence Intubation

Drug Assisted Intubation
## Signs and Symptoms of Hemorrhage by Class

**PARAMETER** | **CLASS I** | **CLASS II** | **CLASS III** | **CLASS IV**
--- | --- | --- | --- | ---
Blood loss | < 15% | 15-30% | 31-40% | > 40%
HR |  |  |  |  
BP |  |  |  |  
PP |  |  |  |  
RR |  |  |  |  
UO |  |  |  |  
GCS |  |  |  |  

<table>
<thead>
<tr>
<th><strong>Base Deficit</strong></th>
<th>0 to -2</th>
<th>-2 to -6</th>
<th>-6 to -10</th>
<th>-10 or less</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Need for blood?</strong></td>
<td>Monitor</td>
<td>Possible</td>
<td>Yes</td>
<td>Massive Transfusion</td>
</tr>
</tbody>
</table>

**Mortality:** 7% → 51%

**Transfused Blood:** 1.5 units → 20.3 units
Damage Control Resuscitation

- 1 L warmed
- Increased mortality (OR 2.89) when > 1 L given
- Switch to blood products early (1:1:1 ratio) > 4 units in ED = MTP
- Prevent/reverse coagulopathy (Rotem/TEG)

87-100% survival if used pre-hospital

PROMMTT (2013)

- Ratios of less than 1:2 had 3-4x increased mortality than 1:1
- Only mattered in the first 24 hours
- After 24 hours, ratios unassociated with mortality

PROPPR (2015)

- 1:1:1 vs 1:1:2
- Reduced mortality from bleeding in first 24 hours (RRR 25%)
- Overall mortality at 24 hr and 30 days not different
**CRASH-2 TRIAL**

**Decreased Mortality**

- < 1 hr = RR 0.68
- 1-3 hr = RR 0.79

**Increased Mortality**

- > 3 hr = RR 1.44

1 gram over 10 minutes

Give within **3 hours** of injury

Repeat 1 gram over **8 hours in hospital**

**THROMBOELASTOGRAPHY**

- **Alpha Angle**: Angle of tangent line from 2mm-20mm
- **K**: Clot formation time: time from 2mm-20mm amplitude.
- **MA**: Maximum Amplitude: Amplitude measured at peak clot strength.
- **LY**: Lysis Index: percent loss of amplitude at 30min after MA

Legend:
- Platelet depletion
- Thrombocytopenia
- Hypo/hypercoagulable states
- Fresh frozen plasma
- Cryoprecipitate
- Enzymatic or mechanical hystereolysis
- Tranexamic acid
LIFE THREATENING INJURIES

**IN**
- Tracheobronchial Injury
  - Blunt trauma: 17%, 23%, 18%, 25%, 14%
  - Penetrating trauma: 75%, 14%, 0.5%, 0.5%, 3%

**OUT**
- Flail Chest
LIFE THREATENING INJURIES

- Airway Obstruction
- Tracheobronchial Tree Injury
- Tension Pneumothorax
- Open Pneumothorax
- Massive Hemothorax
- Cardiac Tamponade
- Traumatic Circulatory Arrest

E-FAST

Sub-xiphoid
1
1

RUQ
2
2

LUQ
3
3

Pelvis
4
4

Right Thorax
5
5

Left Thorax
6
6

US vs CXR

for pneumothorax

<table>
<thead>
<tr>
<th></th>
<th>US</th>
<th>VS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sn</td>
<td>86-98%</td>
<td>28-75%</td>
</tr>
<tr>
<td>Sp</td>
<td>98-100%</td>
<td>100%</td>
</tr>
</tbody>
</table>

Wilkerson, 2010
NEEDLE DECOMPRESSION

14G 3.25 inch

20 cadavers (40 attempts)

Inaba, 2011
ADULT

5th ICS MAL

PEDIATRIC

2nd ICS MCL

FINGER THORACOSTOMY
CHEST THORACOSTOMY

Does size matter?

- Prospective trial
- 353 chest tubes
- 28-32 Fr vs 36-40 Fr
- No difference in...
  - Initial volume drained
  - Complications
  - Reinsertion need
  - Hemo vs pneumo

28-32 Fr

Inaba, 2012

---

Indications for Thoracotomy
(after chest tube in trauma)

<table>
<thead>
<tr>
<th></th>
<th>Immediate output</th>
<th>Ongoing Output</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Adults</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Immediate</td>
<td>&gt; 1.5 L in first hour</td>
<td>&gt; 200 cc/hr over next 2-4 hours</td>
</tr>
<tr>
<td>Ongoing</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Children</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Immediate</td>
<td>&gt; 20 mL/kg in first hour</td>
<td>&gt; 3 mL/kg/hr over next 2-4 hours</td>
</tr>
<tr>
<td>Ongoing</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
AORTIC DISSECTION

Blunt Aortic Injury → CTA

Beta Blockers!
→ HR < 80 bpm
→ MAP 60-70 mmHg

Hemodynamically stable → possible endovascular repair

TRAUMATIC CARDIAC ARREST

The quickest way to a man’s heart is through a Clamshell Thoracotomy
TRAUMATIC CARDIAC ARREST

Operating room with surgeon present is mandatory

First 2 minutes

CPR, IV/IO, Fluids, Epi

Bilateral Chest Decompression

First 3 minutes

Thoracic injury

Direct repair

Anterolateral or Clamshell Thoracotomy with vertical pericardiotomy

Abdominal injury

Clamp aorta

Death when > 30 min and temp > 33C
DIGITAL RECTAL EXAM FOR URETHRAL INJURY

Ball, 2009
- Retrospective review of 41 patients
- Blunt trauma specific

Results
- DRE: 2%
- Blood at the urethral meatus: 20%
- Hematuria prior to catheter insertion: 17%

“DRE remains clinically indicated in patients with penetrating trauma in the vicinity of the rectum, pelvic fractures, and spinal cord injuries…”
PREPERITONEAL PELVIC PACKING

**Cothren, 2007**
- 12 units (pre-PPP) vs 6 units (post-PPP)
- 75% reduction in need for angiography
- No deaths from blood loss
- Lower mortality

“PPP is a rapid method for controlling pelvic fracture-related hemorrhage that can supplant the need for emergent angiography.”
Avoid prolonged hyperventilation with PCO2 <25 mm Hg

**Systolic Blood Pressure Guidelines**
- >100 mm Hg for patients 50–69 years
- >110 mm Hg or higher for patients ages 15–49 or older than 70 years

**Sedation**
- Propofol recommended for the control of increased ICP
- *no improvement of six-month outcomes*

**Seizure Prophylaxis**
- Phenytoin recommended to decrease incidence of early posttraumatic seizures (within seven days of injury).
- Not recommended for preventing late posttraumatic seizures.
- Posttraumatic seizure has not been associated with worse outcomes (IIA)
GOALS OF TREATMENT OF BRAIN INJURY

**Clinical Parameters**
- SBP ≥ 100 mm Hg
- Temperature 36-38 C

**Monitoring Parameters**
- CPP ≥ 60 mmHg
- ICP 5-15 mmHg
- PbtO$_2$ ≥ 15 mmHg
- Pulse Oximetry ≥ 95%

**Lab Values**
- Glucose 80-180
- Hgb ≥ 7
- INR ≤ 1.4
- Na 135-145
- PaO$_2$ ≥ 100 mmHg
- PaCO$_2$ 35-45 mmHg
- pH 7.35-7.45
- Platelets ≥ 75 x 10$^3$/mm$^3$

HEAD INJURY ON ANTICOAGULATION

**Admission for neurologic observation**
- All supra-therapeutically anticoagulated patients
- CT abnormality

**Anticoagulation Reversal**
- Consideration given to short term reversal of anticoagulation

**Timing of repeat Head CT**
- At 12 to 18 hours
- or when even subtle signs of neurologic worsening occurs

Cohen, 2006
ANTICOAGULATION REVERSAL GUIDELINES

Antiplatelets → Platelets, consider DDAVP

Coumadin → FFP, Vit. K, PCC, Factor VIIa

Heparin → Protamine sulfate

Pradaxa → Praxbind, PCC

Xarelto/Eliquis → PCC

PECARN

Pediatric Emergency Care Applied Research Network (PECARN) Criteria for Head CT. Suggested CT algorithm for children younger than 2 years (A) and for those aged 2 years and older (B) with GCS scores of 14-15 after head trauma.
PECARN

Is exam abnormal?

- LOC > 5 seconds
- Hematoma (anything but frontal)
- Headache (severe)
- Vomiting
- Severe Mechanism (think c-spine)
- Parental GCS < 15

Get Head CT

NO

Don't get CT

YES

Shared Discussion

“Larry Hits Head, Very Scared Parents”

Spine and Spinal Cord
### NEW MYOTOME DIAGRAM

<table>
<thead>
<tr>
<th>Muscle Strength Grading</th>
<th>Myotomes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Score</strong></td>
<td><strong>Result</strong></td>
</tr>
<tr>
<td>0</td>
<td>Total paralysis</td>
</tr>
<tr>
<td>1</td>
<td>Palpable or visible contraction</td>
</tr>
<tr>
<td>2</td>
<td>Full range of motion with gravity eliminated</td>
</tr>
<tr>
<td>3</td>
<td>Full range of motion against gravity</td>
</tr>
<tr>
<td>4</td>
<td>Full range of motion, but &lt; normal strength</td>
</tr>
<tr>
<td>5</td>
<td>Normal strength</td>
</tr>
<tr>
<td>NT</td>
<td>Not testable</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>C5</th>
<th>Elbow flexors (biceps)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>C6</td>
<td>Wrist extensors</td>
</tr>
<tr>
<td></td>
<td>C7</td>
<td>Elbow extensors (triceps)</td>
</tr>
<tr>
<td></td>
<td>C8</td>
<td>Finger flexors</td>
</tr>
<tr>
<td></td>
<td>T1</td>
<td>Finger abductors</td>
</tr>
<tr>
<td></td>
<td>L2</td>
<td>Hip flexors</td>
</tr>
<tr>
<td></td>
<td>L3</td>
<td>Knee extensors</td>
</tr>
<tr>
<td></td>
<td>L4</td>
<td>Ankle dorsiflexion</td>
</tr>
<tr>
<td></td>
<td>L5</td>
<td>Long toe extensors</td>
</tr>
<tr>
<td></td>
<td>S1</td>
<td>Ankle plantar flexors</td>
</tr>
</tbody>
</table>

"Key myotomes are used to evaluate the level of motor function…"
CERVICAL SPINE TRAUMA

Canadian C-Spine Rule (CCR)

1. Age > 65 years
2. Dangerous mechanism
3. Paresthesias in extremities
4. Rotate neck 45 degrees left and right

Dangerous Mechanisms
- Fall from > 1 meter/5 stairs
- Axial load of head
- MVC with ejection, rollover, > 60 mph
- Motorized recreational vehicle collision
- Bicycle collision

Imaging indicated if any present

Low risk factors (prior to assessing ROM)
- Simple rear-end MVC
- Sitting position in ED
- Ambulatory at any time
- Delayed onset of neck pain
- No midline cervical tenderness

Stiell, 2003

CERVICAL SPINE TRAUMA

NEXUS Criteria

N - Neuro deficit
E - EtOH (alcohol)/intoxication
X - Extreme distracting injury
U - Unable to provide history (altered LOC)
S - Spinal tenderness (midline)

Imaging indicated if any present
CERVICAL SPINE TRAUMA

Zoe, 2012
• Meta-analysis of 15 studies

Canadian C-Spine
- Sn 90-100%
- Sp 1-77%

NEXUS criteria
- Sn 83-100%
- Sp 2-46%

THORACIC AND LUMBAR SPINAL TRAUMA

• Clinical Exam
  • Pain
  • Midline Tenderness
  • Deformity
  • Neuro deficit
- Sn 78.4%
- Sp 72.9%

• Age ≥ 60
• High-Risk Mechanism
  • Fall
  • Crush
  • Motor vehicle crash with ejection/rollover
  • Unenclosed vehicle crash
  • Auto vs. pedestrian
- Sn 98.9%
- Sp 29.0%

Inaba, 2015
### Musculoskeletal Trauma

#### IV Antibiotics (weight-based dosing guidelines)

<table>
<thead>
<tr>
<th>Open Fractures</th>
<th>1st Generation Cephalosporins (Gram-Pos coverage)</th>
<th>If Anaphylactic PCN allergy</th>
<th>Aminoglycoside (Gram-Pos coverage)</th>
<th>Piperacillin/Tazobactam (Broad-Spectrum Gram-Positive and Neg Coverage)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wound &lt; 1 cm; minimal contamination or soft tissue damage</td>
<td>1st Generation Cephalosporins (Gram-Pos coverage)</td>
<td>If Anaphylactic PCN allergy</td>
<td>Aminoglycoside (Gram-Pos coverage)</td>
<td>Piperacillin/Tazobactam (Broad-Spectrum Gram-Positive and Neg Coverage)</td>
</tr>
<tr>
<td></td>
<td>Cefazolin</td>
<td>Clindamycin</td>
<td>Gentamicin</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&lt; 50 kg: 2 gm q8 hr</td>
<td>&lt; 80 kg: 600 mg q8 hr</td>
<td>&lt; 80 kg: 600 mg q8 hr</td>
<td></td>
</tr>
<tr>
<td></td>
<td>50-100 kg: 2 gm q8 hr</td>
<td></td>
<td>&gt; 80 kg: 900 mg q8 hr</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&gt; 100 kg: 3 gm q8 hr</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wound 1-10 cm; moderate soft tissue damage; comminution of fracture</td>
<td>1st Generation Cephalosporins (Gram-Pos coverage)</td>
<td>If Anaphylactic PCN allergy</td>
<td>Aminoglycoside (Gram-Pos coverage)</td>
<td>Piperacillin/Tazobactam (Broad-Spectrum Gram-Positive and Neg Coverage)</td>
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<td>Cefazolin</td>
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<td></td>
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<td></td>
<td>&gt; 80 kg: 900 mg q8 hr</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&gt; 100 kg: 3 gm q8 hr</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Severe soft-tissue damage and substantial contamination with associated vascular injury</td>
<td>1st Generation Cephalosporins (Gram-Pos coverage)</td>
<td>If Anaphylactic PCN allergy</td>
<td>Aminoglycoside (Gram-Pos coverage)</td>
<td>Piperacillin/Tazobactam (Broad-Spectrum Gram-Positive and Neg Coverage)</td>
</tr>
<tr>
<td></td>
<td>Cefazolin</td>
<td>Clindamycin</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>50-100 kg: 2 gm q8 hr</td>
<td></td>
<td>&gt; 80 kg: 900 mg q8 hr</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&gt; 100 kg: 3 gm q8 hr</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Farmyard, soil or standing water, irrespective of wound size or severity</td>
<td>1st Generation Cephalosporins (Gram-Pos coverage)</td>
<td>If Anaphylactic PCN allergy</td>
<td>Aminoglycoside (Gram-Pos coverage)</td>
<td>Piperacillin/Tazobactam (Broad-Spectrum Gram-Positive and Neg Coverage)</td>
</tr>
<tr>
<td></td>
<td>Cefazolin</td>
<td>Clindamycin</td>
<td>Gentamicin</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&lt; 100 kg: 3.375 gm q6 hr</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>&gt; 100 kg: 4.5 gm q6 hr</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### BILATERAL FEMUR FRACTURES = HIGHER MORTALITY

<table>
<thead>
<tr>
<th></th>
<th>Copeland, 1998</th>
<th>O’Toole, 2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bilateral</td>
<td>26%</td>
<td>7%</td>
</tr>
<tr>
<td>Unilateral</td>
<td>12%</td>
<td>2%</td>
</tr>
</tbody>
</table>
FLUID RESUSCITATION CHANGES

**Electrical Injury**

\[ 4 \text{ ml LR} \times \text{ kg} \times \% \text{TBSA} \text{ for ALL AGES} \]

**Flame or Scald Injury**

\[ 2 \text{ ml LR} \times \text{ kg} \times \% \text{TBSA} \text{ for ages } \geq 14 \text{ years} \]

\[ 3 \text{ ml LR} \times \text{ kg} \times \% \text{TBSA} \text{ for ages } < 14 \text{ years} \]

*Add dextrose containing solution at maintenance if } \leq 30 \text{ kg}*

---

**Trauma in Pregnancy**

---
AVOID CT PRIOR TO TRANSFER

**Onzuka, 2008**
- Retrospective review over 2 years
- 249 trauma patients
- No change in Injury Severity Score
- Delayed transfer by 90 minutes

**Quick, 2013**
- Retrospective review over 3 months
- In-House Interpretation of outside images
  - 223 total CT scans
  - 25 repeat CT scans
  - $4,592 lower cost per patient
- Outside hospital interpretation
  - 320 total CT scans
  - 62 repeat CT scans

ABC-SBAR TEMPLATE FOR TRANSFER OF PATIENTS

**Airway, Breathing and Circulation**
- Identify problems and perform interventions

**Situation**
- Patient name and age
- Referring physician name
- Reporting nurse name
- Indication for transfer
- IV access site, fluid and rate
- Other interventions completed

**Background**
- Event history
- AMPLE assessment
- Blood products
- Medications given (date and time)
- Imaging performed
- Splinting

**Assessment**
- Vital signs
- Pertinent physical exam findings
- Patient response to treatment

**Recommendation**
- Transport mode
- Level of transport care
- Medication intervention during transport
- Needed assessments and interventions
REFERENCES


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