OBJECTIVES

- Identify Life threatening and Common Rural Injuries
- Patient Stabilization and Resuscitation
- Emergent Management of Injuries
- Formulate Plans for Transport

INTRODUCTION

- What is rural?
- Epidemiology of Pediatric Trauma
- Most Common Injuries in Rural setting
- Management of the Life threatening Injuries
- Pediatric Resuscitation
- Stabilization
- Safe Transfer and Where

RURAL?

- There is no universally acceptable and universally applicable definition of rural trauma …
- … when optimal care of the injured is delayed or limited by geography, weather
- distance resources or lack of experience

… nearly 60% of all trauma deaths occur in rural areas
- despite the fact that only 20% of the nation's population live in these areas …

… injury related deaths are 40% higher in rural communities
- than in urban areas...

Report on Injuries in America
- National Safety Council - 2003
- Center for Rural Care Fact Sheet
- University of North Dakota 2003
... 84% of U.S. residents can reach a Level I or Level II trauma center within an hour, but only 24% of residents in rural areas have access within one hour …

- Branas et al. Health Services Research 2000

**EPIDEMIOLOGY**

- Over the past 25 years, injury epidemiology has had a major impact on our understanding of pediatric trauma.

- It has allowed us to identify and quantify specific injury risks, develop prevention and treatment strategies, and monitor their effectiveness.

- Injuries are the leading threat to the health and well-being of young people in our society today.

- About 50% - 80% of pediatric trauma deaths occur in the field.

- Prevention is the key.

- Most trauma systems now have very low preventable death rates.

- It is unlikely that substantial reductions in the overall trauma mortality rate in the United States can be achieved by better trauma care.

- We lack effective treatments for primary brain injuries, the most common cause of death in pediatric trauma.

- A report from the National Pediatric Trauma Registry showed that about 70% of the deaths were caused by central nervous system (CNS) injury.

- Only prevention can significantly reduce these deaths.
• 5 Million deaths worldwide
• >22 Million children injured per year
• Costs = 500 Billion Annually
• Injury is the most common cause of death and disability in childhood
• Every year nearly 1 in 6 children require ED care for treatment of an injury (US)

• Retrospective study 1994
• Pre-hospital run sheet data
• Urban vs. rural
• Age < 17
• Conclusion:
  • Educational initiatives for pediatric care
  • Pre-hospital setting
  • Assessment and stabilization
  • Appropriate procedures
  • ALS, BLS
**Epidemiology of Rural Traumatic Death in Children: A Population-Based Study**

- Vane, Dennis W.; Shackford, Steven R.

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| FIGURE 1. PROPORTIONS OF PEDIATRIC TRAUMA DEATHS BY CAUSE OF DEATH, DEMONSTRATING THE OVERWHELMING NUMBERS OF CHILDREN DYING BEFORE REACHING MEDICAL ATTENTION. MVA, MOTOR VEHICLE ACCIDENT; SUFF, SUFFOCATION; MV, MOTOR VEHICLE; MISC, MISCELLANEOUS. |

| FIGURE 2. PEDIATRIC TRAUMA DEATH RATES BY AGE. |

| FIGURE 3. ETIOLOGIES OF PEDIATRIC TRAUMA DEATHS IN VERMONT. MVA, MOTOR VEHICLE ACCIDENT; SUFF, SUFFOCATION; MV, MOTOR VEHICLE; UNSPEC ENVIRON, UNSPECIFIED ENVIRONMENT; MISC, MISCELLANEOUS. |

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**Figure 7: Unintentional Injury Death Rates among Children 0 to 18 Years, by Cause, United States, 2000 - 2010**

- Data Source: COINS, National Vital Statistics System.
MOST COMMON

- The most common types of pediatric trauma are:
  - Motor vehicle accident (number one cause of pediatric deaths in the U.S.)
  - Suffocation
  - Drowning
  - Poisoning
  - Fire and/or burn
  - Fall

INCIDENCE AND MORTALITY OF PEDIATRIC TRAUMA

<table>
<thead>
<tr>
<th>Mechanism</th>
<th>Incidence (%)</th>
<th>Mortality (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stab</td>
<td>9</td>
<td>3</td>
</tr>
<tr>
<td>Fall</td>
<td>27</td>
<td>&lt;1</td>
</tr>
<tr>
<td>MVA - occupant</td>
<td>21</td>
<td>4</td>
</tr>
<tr>
<td>MVA - peds struck</td>
<td>12</td>
<td>5</td>
</tr>
<tr>
<td>Bicycle</td>
<td>9</td>
<td>2</td>
</tr>
<tr>
<td>Penetrating</td>
<td>8</td>
<td>9</td>
</tr>
<tr>
<td>Cannibal Wound</td>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td>Stabbing</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Crush</td>
<td>&lt;1</td>
<td>1</td>
</tr>
</tbody>
</table>

From Roger’s Textbook of Pediatrics
Intensive Care, fourth edition

LIFE THREATENING INJURIES

- Airway Compromise
- Traumatic Brain Injury
- Thoracic Injuries
- Abdominal Injuries
- Burns
Smaller bodies mean more kinetic injury into a smaller space → impact on multiple organs
Larger BSA → heat loss
Anterior liver and spleen, mobile kidneys
Immature bone has increased elasticity → more soft tissue injury (misleading lack of fractures)
Head: body greater, cranial bones thinner
More robust response to catechol driven vasoconstriction → preserved blood pressure until catastrophic shock ensues
More likely to suffer a respiratory than cardiac arrest

"Scoop and run" vs. "stay and play"
Out of hospital airway management

Improved outcomes associated with care in a pediatric trauma center/hospital with PICU
Get to the closet ED for stabilization
Loss of airway and IV access twice as common during transport, 10 times more common if not a specialized team

THE PEDIATRIC AIRWAY
ANATOMIC DIFFERENCES AND TRAUMA MANAGEMENT

- Relatively larger tongue – most common cause of airway obstruction
- Larger adenoids
- Floppy omega shaped epiglottis
- Larynx appears more cephalad and anterior
- Cricoid ring is narrowest part of airway
- Narrow tracheal diameter, smaller distance between rings
- Shorter tracheal lengths (4 cm newborn, 7 in 18 month old)
- Large airways more narrow
AIRWAY AND C SPINE

- Assume C spine injury in pediatric trauma
  - Jaw thrust, oral airway
- Assume full stomach/RSI indicated
  - Induction agents – risks of propofol, ketamine, etomidate and succinylcholine
- Pre-oxygenation
- Avoid nasal intubation with severe facial/head trauma. Blind NI less successful in children
- Consider cuffed ETT
- Needle cricothyroidotomy (no slash trachs in kids)
- Orogastric tube to decompress stomach

A NOTE ABOUT C SPINES

- More likely to have high cervical trauma under 8 years old (OA fulcrum)
- Radiographs are over and under-read
- SCIWORA
- Harder to immobilize
- CT scan vs. MRI

BREATHING

- Hypoxia and inadequate ventilation
- Most common causes of ,
- Pediatric cardiopulmonary arrest
BREATHING

- Apply 100% oxygen immediately while doing primary survey
- Watch for age-appropriate respiratory rates
- Hypercarbia/inadequate ventilation often under appreciated
- Pneumothorax more difficult to diagnose by auscultation due to transmitted breath sounds. If hemodynamically unstable, needle chest early (tension pneumothorax)
- Respiratory arrest from C spine injury

THORACIC INJURY

- 4 – 25% of pediatric trauma, up to 40% mortality
- Low SBP, elevated RR, external thoracic injury or femur fracture associated with intrathoracic injury
- Compliant chest wall
- Mobile sternum
- Pneumothorax
- Hemothorax
- Aortic injury accounts for 14% of mortality

MOST LIFE THREATENING

- Tension pneumothorax
- Cardiac tamponade
- Flail chest
- Open pneumothorax
- Massive hemothorax

TENSION PNEUMOTHORAX

- Tension Pneumothorax
- Cardiac Tamponade
- Flail Chest
- Open Pneumothorax
- Massive Hemothorax

TAMPOONADE

- Cardiac tamponade

FLAIL CHEST
CIRCULATION

- Intravenous access
  - 3 attempts, 90 seconds, or obtunded
  - Large bore PIV is optimal
  - CVL or cut down PIV
  - I/O- limits 25mL/min

- Control of hemorrhage
  - Direct pressure over bleeding
  - Tourniquets?
  - Hemorrhage into thorax, retroperitoneum, thigh or intracranial in infants
  - More than 3cc/kg/hour from chest tube is an indication for operation

- Aortic injury is 2nd cause of death after TBI

- Peripheral Palpable pulse = SBP >80 mmHg
- Palpable central pulse = pressure of 60-80 mmHg

- Hypotension is a late finding correlating to loss of 30% to 45% of circulating blood volume
- Monitor for poor perfusion or confusion
- 20cc/kg warmed isotonic solution X 2 then PRBC
- Crystalloid vs. colloid?
  - 0.9 NS or LR
  - Colloids
    - 3% saline
    - Albumin
- Blood products
- Over-resuscitation
  - Edema, abd compartment syndrome, ARDS, hypotension

SHOCK

OPEN PNEUMOTHORAX

MASSIVE HEMOTHORAX
• 20 ml/kg of crystalloid
• If 40mL/kg already given and on third bolus
• Infusion of 10mL/kg of PRBC considered

TRAUMATIC BRAIN INJURY

Among children ages 0 to 14 years, TBI results in an estimated:
- 2,685 deaths;
- 37,000 hospitalizations
- 35,000 emergency department visits annually

What causes TBI?
- Falls (28%);
- Motor vehicle-traffic crashes (20%);
- Struck by/against events (19%); and
- Assaults (11%)


ABDOMINAL INJURY

• Thin body wall and closely spaced organs
• Any external markings or tenderness are ominous
• Gastric decompression to benefit ventilation
• Diaphragmatic rupture
• Gastric rupture
• Bowel injury injury
• Splenic or hepatic injury
• Renal injury

Table 2: The Glasgow Coma Scale

<table>
<thead>
<tr>
<th>Standard</th>
<th>Score</th>
<th>Pediatric</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eye opening</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spontaneous</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>To speech</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>To pain</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Verbal response</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Orientation</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Confused</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Inappropriate words</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Inappropriate behavior</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Motor response</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Obey commands</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Spontaneous movement</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Location in pain</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Withdraw to touch</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Withdraw to pain</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Amputated response</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Amputated response</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

Vascular injuries – SAH and IVH serve as markers of severity

CONTROL OF SECONDARY INJURY

- Mass effect
  - Parenchyma
  - CSF
  - Blood
- Hypoxia
- Ischemia
  - Target thresholds in children?

MANAGEMENT OF TBI:
CONTROL SECONDARY INJURY

- Normoventilation: PCO2 35-38
- ETCO2 monitoring
- Osmolar therapy -
  - Mannitol
  - Hypertonic Saline: 25 – 1.0 g/kg or continuous infusion 0.1-1.0 mL/kg/hr
- ICP and CPP management – what numbers are adequate in children? Definitive care
- Glycemic control – not a simple answer
- Coagulopathy -30% incidence of DIC in children with severe TBI
INHALATION INJURY?

- Face and neck burns
- Sloughing of the eyelids and nasal vestibule
- Carbon deposit in the mouth and nose and oropharyngeal region
- Acute inflammatory changes in the mucous membranes, including eyes
- Blepharitis
- History of inhaled material and/or confinement in a burning environment
- Explosions with burns to head and torso
- Carbon monoxide level greater than 10% in a patient who was involved in a fire

### Table 3: Age-appropriate CPP thresholds in severe traumatic brain injury (according to Rice et al. [60] and Jakhe et al. [60]. CPP: cerebral perfusion pressure)

<table>
<thead>
<tr>
<th>Age group (years)</th>
<th>CPP threshold (mmHg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-1</td>
<td>60</td>
</tr>
<tr>
<td>1-9</td>
<td>60-65</td>
</tr>
<tr>
<td>10-13</td>
<td>70</td>
</tr>
<tr>
<td>+ 13</td>
<td>70-80</td>
</tr>
</tbody>
</table>

BURNS

- ABCD
- Airway – intubation
- Inhalation injury?
- Take off all clothes – expose
- Iv access
- If > 20% burns – parkland formula
- Estimate resuscitation in first 24 hours
- 2-4mL LR x kg x % BSA
• Palm of the patient reps. 1%
• Partial thickness or full thickness
• Carbon monoxide?
• Closed space?
• Half live of CO if 250 minutes
• CO has 240 x stronger affinity for hemoglobin
• 100% 02 40 minute half life

TRANSPORT

• 5 Decisions for each Interfacility Transport
• Availability of Transport Resources
• Team and vehicle/aircraft
• Weather Conditions / Traffic Conditions
• Bed Availability and Subspecialty Availability &
• Patient Acuity
• Distance
• Cost
• Minimal Monitoring Equipment
• EKG Monitor
• Pulse Oximeter
• ? End Tidal CO2 Monitor
• Defibrillator with batter backup and transcutaneous pacing
• capability
• Oxygen Analyzer and Oxygen Tank
• Ventilator Appropriate for Infants & Children & Adults
• Infusion Pumps
• Portable Suction Unit
• Noninvasive Blood Pressure Monitor

• Inappropriate Judgments
• The faster the patient is on the way (i.e. out of my ED) the better
• No evidence that Speed of Transfer regardless of
• level of care is beneficial to Patient
• Exceptions: Immediate Surgical Emergencies
• Safety Enroute with Vehicles
• Safety Enroute with Helicopters
• Communication
  • Initial Physician to Physician and nurse to nurse Conversation
  • Method of Transport
  • Nature of Transport: Isolette, Pediatric Stretcher, Infant/Pediatric Ventilator, etc.
  • Team Composition
  • Reason for Mode of Transport (patient acuity, distance, weather, etc.)
  • Anticipated/required Equipment

• Method of Transport
  • Transfer by Private Vehicle
  • Use of Local ambulance Service
  • Local EMS Personnel
  • Accompanying Support Personnel from Referring Hospital
  • Use of a Helicopter Transport Team with most experience in trauma victims and patients
  • Pediatric Critical Care Transport Team or Neonatal Transport Team
  • Fixed Wing Transports

• Communication
  • To Transport Personnel
  • Airway Maintenance
  • Fluid Volume Replacement
  • Anticipated Special Procedures
  • Scoring System:
    • Glasgow Coma Score
    • Revised Trauma Score
    • Pediatric Trauma Score
  • From Transport Personnel
  • Departure, Enroute, Arrival at Receiving Hospital

CASE
• 17 yr. female ejected MVC
  • Found 30 ft from vehicle
  • Three other deaths in the vehicle
  • Hypothermic & hypotensive responding to fluid
  • Decreased GCS

Transferred to OSH

OSH
• GCS improved to 14
• BP stable after 2 L crystalloid
• CXR completed
  • Widened mediastinum
  • Diagnosed Aortic Injury

CXR
Discussion with OSH to keep BP systolic 100-110 range
HR target < 130
Started on Esmolol for HR 150, BP 110 systolic,
Blood was sent with pt. sent by air transport (approx. 35 min.) transport time.

ARRIVAL AT LEVEL II
Evaluated by ED & Trauma surgeon
Recent rural trauma development course taken by staff at OSH facility.

BURN
12 yr. burn
- Bonfire with explosion after aerosol can thrown into fire
- OSH facility contacts Pediatric Center with report of 40% burn to face, chest, arms, legs.
- Denies inhalation injury, pt. non-intubated
- Received 2 L fluid PTA

REFERENCES
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