got access?
Pediatric Trauma Care in the United States

Michael L. Nance, MD
Templeton Chair in Pediatric Trauma
Director, Pediatric Trauma Program
Children’s Hospital of Philadelphia
• One in five children (14 million) injured each year

Why do we care about trauma and kids?
• 25% of trauma patients are pediatric
• 9 million ED visits
• 250,000 admissions
• 17,000 deaths
• $50.5 billion annual costs
  – (Iraq 2003-$53 billion)
"If a disease were killing our children in the proportions that injuries are, people would be outraged and demand that this killer be stopped."

--C. Everett Koop, M.D.
NIH spending on select diseases
2010

<table>
<thead>
<tr>
<th>Disease</th>
<th>Amount (millions)</th>
<th>2007 Mortality (deaths)</th>
<th>2010 NIH Spending (millions)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Childhood Injury</td>
<td>$8,280</td>
<td>39</td>
<td>$15</td>
</tr>
<tr>
<td>Transmissible Spongiform Encephalopathy</td>
<td>51</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Methamphetamine</td>
<td>87</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anthrax</td>
<td>130</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pediatric AIDS</td>
<td>231</td>
<td></td>
<td>$15 million</td>
</tr>
</tbody>
</table>

2007 mortality data, 2010 NIH data
History of Trauma Care
(Brief)

- Achilles (Illiad, 800 B.C.) caring for the wound of his cousin in the Trojan War
- Hippocrates (460–377 B.C.) for abdominal wounds, traction for fractures
- Galen 130–200 A.D. recognized by Marcus Aurelius for his care of the gladiators
History of Trauma Care

Amboise Parè (c. 1510-1590)

- Official surgeon to kings Henry II, Francis II, Charles IX and Henry III
- Leader in development of battlefield medicine
- Observed antiseptic properties of turpentine
- Introduced ligature of arteries rather than cauterization
History of Trauma Care

Dominique Larrey (1766-1842)

- Surgeon in the Army of Napoleon
- Pioneered triage
- Considered first military surgeon
- Credited with 200 amputations at the Battle of Borodino (1 every 7.2 minutes). Larrey could amputate at the hip joint in 15 seconds and the shoulder in 11 seconds
- Developed the “flying Ambulance”
History of Trauma Care

Florence Nightingale, 1820-1910

- Active in the Crimean War (1854-1856)
- Worked with 37 other nurses to coordinate medical relief activities, emphasized sanitation and hygiene
- Striking reduction of death from disease established new standards for military hospitals
- Benefits of antisepsis (Lister) not used formally until Spanish-American war (1898)
Transportation and Trauma Care
History of Trauma Care

Forward Surgical Care

• Renal failure recognized as frequent cause of death or morbidity (shock)

• Korean conflict moved hospital closer to patient (M.A.S.H.)

• Vietnam Conflict saw increased use of helicopter transport (minutes)

• Operation Iraqi Freedom (I and II) saw implementation of the Forward Resuscitative Surgery System

• Small medical teams (6-8 persons) deployed in the battle space
History of Trauma Care in the US

Lethality

- Revolutionary War: 42%
- Civil War: 33%
- World War 1: 21%
- World War 2: 30%
- Korean Conflict: 25%
- Vietnam War: 24%
- Iraq/Afghanistan: 10%

Time and access to care matter
Civilian Trauma Systems

- Organized trauma systems began to take shape in the 1960s and 1970s.
- National Highway Safety Act of 1966
• State trauma systems were developed in Maryland and Illinois
• The American College of Surgeons Committee on Trauma (ACSCOT) in 1976 published ‘Optimal Care for the Injured Patient’
• ATLS course unveiled, 1978 with advocacy of “Golden Hour”
• Institute of Medicine recognizes Trauma System as a model of health care delivery
• Trauma systems regulated at the state level with no national central accrediting body
• Modern pediatric trauma care took several more decades to evolve

• Emergency Medical Services for Children (EMS-C) program created in 1984

• Meant to ensure optimal integration of ill and injured children into EMS systems

• IOM (2006) and Healthy People 2010 recognized fragmentation and variation in delivery of pediatric emergency care
Recommended coordination, regionalization, and accountability

“...ensure that each patient receives the most appropriate care, at the optimal location, with the minimum delay.”

Emergency Care for Children: Growing Pains, Institute of Medicine, 2006
Do Trauma centers improve outcome?
• Methodologically challenging question
• Most studies would suggest Trauma Centers beneficial
• Panel studies and registry based studies—yes
• Registry based studies demonstrate about 15% reduction in mortality
• Impact of establishing trauma center in region—15-20% reduction
A Systematic Review and Meta-Analysis Comparing Outcome of Severely Injured Patients Treated in Trauma Centers Following the Establishment of Trauma Systems

Brian Celze, PhD, Joseph Tepas, MD, Barbara Lergland-Orban, PhD, Etienne Pracht, PhD, Linda Papa, MD, Lawrence Lottenberg, MD, and Lewis Flint, MD

The Journal of Trauma: Injury, Infection, and Critical Care

J Trauma 2006
Overall, 15% reduction in mortality
A National Evaluation of the Effect of Trauma-Center Care on Mortality

Ellen J. MacKenzie, Ph.D., Frederick P. Rivara, M.D., M.P.H.,
Gregory J. Jurkovich, M.D., Avery B. Nathens, M.D., Ph.D.,
Katherine P. Frey, M.P.H., Brian L. Egleston, M.P.P., David S. Salkever, Ph.D.,
and Daniel O. Scharfstein, Sc.D.

- Most definitive study to date, NSCOT
- 20% risk reduction for patients treated at a TC
- Looked at outcome of more than 18,000 patients treated at TCs (18) or non-TCs (51) in 14 states
- Risk reduction limited to patients <55 yrs
- Risk reduction more pronounced in higher AIS groups
- All patients treated during the same time period

Mackenzie, et al  NEJM 2006
**What Price Commitment: What Benefit? The Cost of a Saved Life in a Developing Level I Trauma Center**

Michael F. Rotondo, MD, Michael R. Bard, MD, Scott G. Sagraves, MD, Eric A. Toschlog, MD, Paul J. Schenarts, MD, Claudia E. Goettler, MD, Mark A. Newell, MD, and Matthew J. Robertson, MBA

**TABLE 9. Total Number of Lives Saved**

<table>
<thead>
<tr>
<th>ISS</th>
<th>Age (yr)</th>
<th>Saved Lives</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>18–54</td>
<td>65*</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>173*/207</td>
</tr>
</tbody>
</table>

- Demonstrated 173 lives saved at a cost of $87,000/life over pre-TC expenditures

Rotondo, J Trauma 2009
The Value of Trauma Center Care

Ellen J. MacKenzie, PhD, Sharada Weir, PhD, Frederick P. Rivara, MD, MPH, Gregory J. Jurkovich, MD, Avery B. Nathens, MD, PhD, MPH, Weiwei Wang, PhD, Daniel O. Scharfstein, PhD, and David S. Salkever, PhD

• Secondary analysis of NSCOT data
• Cost effectiveness estimated as difference in cost from TC vs. non TC divided by life years gained (and lives saved)
• Added cost per treatment was $36,319 per life year gained ($790,931 per life)
• Cost effectiveness more favorable for younger patients and more severe injuries

Mackenzie, J Trauma, 2010
The Value of Trauma Center Care

Ellen J. MacKenzie, PhD, Sharada Weir, PhD, Frederick P. Rivara, MD, MPH, Gregory J. Jurkovich, MD, Avery B. Nathens, MD, PhD, MPH, Weiwei Wang, PhD, Daniel O. Scharfstein, PhD, and David S. Salkever, PhD

Mackenzie, J Trauma, 2010
# The Value of Trauma Center Care

*Ellen J. MacKenzie, PhD, Sharada Weir, PhD, Frederick P. Rivara, MD, MPH, Gregory J. Jurkovich, MD, Avery B. Nathens, MD, PhD, MPH, Weiwei Wang, PhD, Daniel O. Scharfstein, PhD, and David S. Salkever, PhD*

## Table 5. Cost-Effectiveness Ratios for Selected Life-Saving Interventions

<table>
<thead>
<tr>
<th>Intervention</th>
<th>Comparator</th>
<th>Target Population</th>
<th>Incremental Cost-Effectiveness Ratios(^a)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prophylactic implantation of an implantable cardioverter defibrillator (ICD)(^{35})</td>
<td>Conventional treatment</td>
<td>Patients at risk of sudden death because of left ventricular systolic dysfunction</td>
<td>$25–51 per QALY added (in thousands of US $2005)</td>
</tr>
<tr>
<td>Administration of drotrecogin alfa (activated)(^{34})</td>
<td>Usual care</td>
<td>Adults with severe sepsis</td>
<td>$34–70 per QALY added (in thousands of US $2003)</td>
</tr>
<tr>
<td>Mechanical ventilation and continued aggressive care(^{34})</td>
<td>No mechanical ventilation or mechanical ventilation withheld</td>
<td>Adults with acute respiratory failure</td>
<td>$33–147 per QALY added (in thousands of US $2003)</td>
</tr>
<tr>
<td>Public access defibrillation (PAD)(^{33})</td>
<td>Standard emergency medical service agency</td>
<td>Persons in cardiac arrest</td>
<td>$27–57 per QALY added (in thousands of US $2003)</td>
</tr>
<tr>
<td>Reducing response time for cardiac arrest(^{33})</td>
<td>Existing emergency medical service agency</td>
<td>Persons in cardiac arrest</td>
<td>$40–368 per QALY added (in thousands of US $2003)</td>
</tr>
<tr>
<td>Renal dialysis, current practice(^{32})</td>
<td>Next least costly strategy</td>
<td>Persons with end-stage renal disease</td>
<td>Average of $129 per QALY added (in thousands of US $2003)</td>
</tr>
</tbody>
</table>

\(^a\) Ranges in CERs reflect differences in specifics of the intervention, comparator, target population, and methods for estimating costs and effectiveness across studies.
There appears to be an outcome (in selected groups) and cost benefit to TC care

But…

Majority of these studies excluded children

Is outcome improved for children treated at a (pediatric) trauma center?
Trends in Operative Management of Pediatric Splenic Injury in a Regional Trauma System

Daniela H. Davis, MD, MSCE*†; A. Russell Localio, JD, MS‡; Perry W. Stafford, MD§; Mark A. Helfaer, MD‖; and Dennis R. Durbin, MD, MSCE†¶

Davis, Pediatr 2005
Variation in the Management of Pediatric Splenic Injuries in New England

David P. Mooney, MD, and Peter W. Forbes, MA

Table 7  Isolated Splenic Injuries and Patients with Multiple Injuries, Adjusted Operative Management Rates, PSs vs. NPSs

<table>
<thead>
<tr>
<th></th>
<th>Isolated Splenic Injury</th>
<th>Multiple Injuries</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>PSs</td>
<td>NPSs</td>
<td>p Value</td>
</tr>
<tr>
<td>%Op</td>
<td>11</td>
<td>30</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>

Operative rates after adjustment through direct standardization.
Multiple injuries, any nonsplenic AIS score of 2 or greater; PSs, pediatric surgeons; NPSs, nonpediatric surgeons; %Op, the percentage of children with a splenic operation recorded.
Variation in the Management of Pediatric Splenic Injuries in the United States

David Patrick Mooney, MD, David H. Rothstein, MD, and Peter W. Forbes, MA
Pediatric Trauma Centers provide different care…

…but is it better care?
Impact of Pediatric Trauma Centers on Mortality in a Statewide System

Douglas A. Potoka, MD, Laura C. Schall, MS, Mary J. Gardner, RN, Perry W. Stafford, MD, Andrew B. Peitzman, MD, and Henri R. Ford, MD

| Table 4 Mortality Rate by Trauma Center, Injury Severity, and Injury Type |
|--------------------------|----------------|----------------|----------------|----------------|
|                          | PTC (%)        | ATC AQ (%)     | ATC I (%)      | ATC II (%)     |
| Overall                  | 187/5189 (3.6) | 156/3636 (4.3) | 97/1207 (8.0)  | 157/3319 (4.7) |
| ISS < 15                 | 39/3945 (0.99) | 16/2503 (0.64) | 17/868 (1.96)  | 19/2466 (0.77) |
| ISS > 15                 | 148/1244 (11.9)| 140/1133 (12.4)| 46/213 (21.6)  | 138/853 (16.2) |
| Head injury<sup>a</sup>  | 82/1251 (6.6)  | 87/986 (8.8)   | 46/216 (21.3)  | 80/727 (11.0)  |
| Liver injury<sup>a</sup>| 20/220 (9.1)   | 38/186 (19.4)  | 12/66 (18.2)   | 31/96 (32.3)   |
| Spleen injury<sup>a</sup>| 15/259 (5.8)   | 38/223 (17.0)  | 9/54 (16.7)    | 21/236 (8.9)   |

<sup>a</sup> Significant difference at p < 0.05.
• 3.15% reduction in mortality if treated in a DTC

• Further 4.84% reduction in mortality if treated at pediatric DTC rather than DTC

Do pediatric patients with trauma in Florida have reduced mortality rates when treated in designated trauma centers?


• Compared mortality at non-trauma center, designated trauma center and pediatric designated trauma center

• 27,313 patients evaluated

Pracht, J Ped Surg 2008
There may be benefit to treatment at a (pediatric) trauma center

But…

Are kids typically treated at Trauma Centers or Pediatric Trauma Centers?
### Who cares for pediatric trauma patients?

<table>
<thead>
<tr>
<th></th>
<th>All Subjects</th>
<th>Young (&lt;5yrs)</th>
<th>Severely-injured (ISS&gt;15)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level I PTC</td>
<td>19.5%</td>
<td>39.6%</td>
<td>51.9%</td>
</tr>
<tr>
<td>Level I or II PTC</td>
<td>27.1%</td>
<td>49.1%</td>
<td>60.5%</td>
</tr>
<tr>
<td>Level I PTC or Adult TC</td>
<td>42.8%</td>
<td>49.0%</td>
<td>69.7%</td>
</tr>
<tr>
<td>Level I or II PT or Adult TC</td>
<td>67.4%</td>
<td>63.1%</td>
<td>76.7%</td>
</tr>
<tr>
<td>Non-Trauma Center (TC)</td>
<td>32.7%</td>
<td>30.7%</td>
<td>16.7%</td>
</tr>
</tbody>
</table>

Myers PAS, 2011
Outcomes and delivery of care in pediatric injury

John C. Densmore, Hyun J. Lim, Keith T. Oldham, Karen S. Guice

Table 2  Site of care (NACHRI designation)

<table>
<thead>
<tr>
<th></th>
<th>0-10 y, ISS &gt;15 (%)</th>
<th>All patients (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Children’s hospital</td>
<td>26.8</td>
<td>10.7</td>
</tr>
<tr>
<td>Children’s unit</td>
<td>38.1</td>
<td>23.5</td>
</tr>
<tr>
<td>Adult hospital</td>
<td>35.1</td>
<td>65.8</td>
</tr>
</tbody>
</table>

B. All patients

<table>
<thead>
<tr>
<th></th>
<th>0.9</th>
<th>8.9</th>
<th>20.2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Children’s hospital</td>
<td>2.4</td>
<td>17.2</td>
<td>32.4</td>
</tr>
<tr>
<td>Children’s unit</td>
<td>1.4</td>
<td>9.7</td>
<td>22.2</td>
</tr>
</tbody>
</table>

$P < .0001$, $\chi^2 P < .0001$, $\gamma^2 P < .0001$, $\gamma^2$
Is access to trauma care equal in the United States?
Trauma Resource Allocation Model for Ambulances and Hospitals (TRAMAH)

- Integer programming optimization model
- Objective to maximize access for severely injured people within ceiling times
- Accounts for both ground and air transport to a trauma center
- Can show existing access and the impact of system changes on access
PA 45 mins By Driving Only With Neighboring States

Land Coverage is 17%
P. Pop Coverage is 56%

Trauma Centers

0 10 20 40 60 80 Miles
Trauma Center – Helicopter Depot Pairs

60 minutes

TC  60 minutes  HD

30 mins  30 mins

TC  HD
Driving and Flying
(within 45 mins)

Land Coverage is 65.7 %
Pop Coverage is 92.4%

* Helipads
● Trauma Centers

0 10 20 40 60 80 Miles
Trauma Access

96.4% of population with access to level I/II trauma centers in 60 minutes

http://tramah.cml.upenn.edu/CML.TraumaCenters.Web/

Branas, JAMA 2005
Transportation types

84.1% of population with access to level I/II trauma centers within 60 minutes

Branas, JAMA 2005
How about access to pediatric trauma resources?

What are pediatric trauma centers and where are they located?
• Methodology similar to adult study
• Needed to create inventory of centers
• Used ACS data, state data, phone calls
• Included “candidate” centers
• Drive time and flight time
• 170 centers in the US
• 77.5% of pediatric population within 1 hour (flying or driving)
• 14 million children without PTC access within an hour
• Varied by state from 0-100%

Nance, Arch Ped Adol Med, 2009
Does access vary by rurality?
Does rurality impact trauma-related outcome?
Why kids die...

- Firearm
- MVC
- All Injury

Most Urban to Most Rural County Type vs Relative Rate
• (Pediatric) Trauma Centers improve care over non-Trauma centers
• Pediatric Trauma Centers may offer improved survival and other benefits over TC and/or non-TC
• Access to TC-based care in the US is not equal in either adult or pediatric populations
• Less access to TC-based care in more rural areas
• Trauma mortality is higher in rural areas

Access likely impacts outcome...

...but direct evidence is lacking