Objectives

- What are the benefits of trauma center care?
- Are all trauma centers created equal?
  - What makes a “high quality” trauma center?
- Do trauma systems save lives?
- Can we raise the bar?
A tale of two counties
West & Trunkey, 1979

- Orange County
  - Trauma patients transported to nearest of 39 facilities
- Preventable deaths: 43%

- San Francisco County
  - Trauma patients transported to 1 centrally located trauma facility
- Preventable deaths: 1%

NSCOT - National Study of Cost and Outcomes in Trauma Care
- Prospective cohort study
- 18 level I trauma centers and 51 large non-designated centers in 15 urban regions
- Extensive data collection to allow for risk adjustment
- Follow-up x 1 year

The NEW ENGLAND JOURNAL of MEDICINE

SPECIAL ARTICLE


A National Evaluation of the Effect of Trauma-Center Care on Mortality

- J.M. 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. Sullister, Ph.D.,
  - and Daniel O. Scharfmann, Sc.D.
National Evaluation of the Effect of Trauma Center Care on Mortality

NSCOT
- Is trauma center care associated with better functional outcomes among survivors?
  - SF-36, functional capacity, return to work
  - Modest benefit (SF-36 scores) only among those with severe lower extremity trauma (J Bone Joint Surgery, 2008)
- Are trauma centers cost effective?
  - One year costs: $80,232 in trauma centers vs $58,320 in non-trauma centers
  - $36,319 per life-year gained or $790,931 per life saved
  - 50-100k per life year gained is considered acceptable

Trauma-related deaths
- Airway
- Breathing
- Circulation – hemorrhage control
- Evacuation of intracranial hematoma
- ICU care
  - 1st 24 hrs
  - All the rest
Do Trauma Centers Do It Faster?
Haas & Nathens, JACS, 2009

<table>
<thead>
<tr>
<th>Risk of death</th>
<th>Time to OR (hrs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brain Injury+Mass Effect</td>
<td>Penetrating Trunical Injury+Shock</td>
</tr>
<tr>
<td>Trauma centre</td>
<td>40% lower</td>
</tr>
<tr>
<td>Non-designated centre</td>
<td>3.6</td>
</tr>
</tbody>
</table>

ICU Care & Mortality After Injury
Nathens, Ann Surg, 2006

- Intensivist-model ICU
- Distinct ICU service (led by an intensivist) or were comanaged with an intensivist (a physician board-certified in critical care)
- Level 1 trauma centres: 80% intensivist model
- Non-designated centres: ~10% intensivist model

Trauma mortality as a function of ICU model

- 22% lower risk of death in closed ICU's
- Effects varied
  - Greatest effect if ICU director was a surgeon
  - Elderly patients derived the greatest benefit
Variations in trauma center care

- Care in a trauma center is associated with a lower risk of death after severe injury
- Experience?
- ICU care?
- ...but are all trauma centers created equal?

Variation in TBI mortality

Trauma center volume & outcome

Nathens, JAMA, 2001
Volume & outcome: implications

- Concentration of care in relatively few centers appears to be beneficial.
- ...but consider
  - Benefits only evident in the sickest patients (~5%)
  - Few centers in the US care for >650 ISS>15 per annum
- Fewer centers limits timely access to care
- Balance between access to care (benefits many) and concentration of care (benefits few)

Why not figure out what the higher volume centers are doing right?

ACS TQIP

Valid, Reliable, Standardized Data
Risk-Adjusted Performance Measurement
Feedback to Trauma Centers

Monitor Performance
Promote Structures and Processes of High Performers
Trauma Quality Improvement

- Traditional approach to trauma quality improvement activities
  - Identify sentinel events
  - Compare this year’s performance to last year's
  - Focused case reviews
  - Few insights into the quality of care
  - “Quality” simply reflects consistency, rather than a high level of performance

Measurement of Quality

Structure  Process  Outcome

Quality defined by structures & processes
Selected Structural Elements

- Dedicated trauma surgeon on call (2.8)
- Published backup call schedule (2.9)
- Commitment of institutional governing body and staff to become a trauma center (5.1)
- Trauma medical director on call roster (5.6) and member/participant of national/regional trauma organizations (5.8)
- Multidisciplinary peer review committee (5.18)
- Operating room staffed and immediately available (11.15)
- Operating microscope and cardiopulmonary bypass 24/7 (11.23)

Selected Processes

- Trauma program must continuously evaluate its processes and outcomes (5.2)
- Seriously injured patients admitted to/evaluated by credentialed trauma providers (5.12)
- Attendance threshold of 80% for presence in the ED (6.6)
- Adequate attendance by general surgery at multidisciplinary peer review (6.10)
- Attending neurosurgeon available for consultation (8.5)
- Neurosurgeon attends >50% of multidisciplinary peer review committee meetings (8.2)

Where does TQIP fit?

<table>
<thead>
<tr>
<th>Structure</th>
<th>Process</th>
</tr>
</thead>
<tbody>
<tr>
<td>TQIP</td>
<td>Outcome</td>
</tr>
<tr>
<td>Mortality</td>
<td>Rates of PE</td>
</tr>
<tr>
<td>Rates of unplanned return to ICU</td>
<td></td>
</tr>
</tbody>
</table>
TQIP participation

Lessons learned

- Very challenging to identify what’s different about "high performers".
- No center is a high performer in all areas
  - Blunt multisystem injuries
  - Penetrating
  - Shock
  - TBI
  - Elderly
Does high quality care translate into benefit for the elderly?

External Benchmarking of Trauma Center Performance: Have We Forgotten Our Elders?

What is the “right stuff” for a trauma center?

- It is unlikely one aspect of care; not one protocol; not one guideline or adherence to guidelines
- It is the “stuff” that is much harder to change
  - Commitment,
  - Effective communication
  - Experience
  - Teamwork
- ...and harder to measure
Structure-Process-Outcome Relationships

<table>
<thead>
<tr>
<th>Structure-Outcome (n=208)</th>
<th>Structure-Process (n=53)</th>
<th>Process-Outcome (n=36)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive</td>
<td>72 (34%)</td>
<td>32 (60%)</td>
</tr>
<tr>
<td>Negative</td>
<td>42 (20%)</td>
<td>7 (13%)</td>
</tr>
<tr>
<td>Nonsignificant</td>
<td>94 (45%)</td>
<td>14 (26%)</td>
</tr>
</tbody>
</table>

Hearld, Medical Care Research & Review, 2008

Structure: In-house trauma surgeons

- Six studies - no differences in outcome
  - Helling, J Trauma, 2003 (OH less time to OR)
  - Arbabi, Arch Surg, 2003, (Surgical critical care fellowship associated with lower risk of death)
  - Fulda, J Trauma, 2002 (Response times 4 vs 14 min)
  - Kheterpal, J Trauma, 1999 (IH less time to OR for penetrating)
  - Luchette, J Trauma, 1997 (IH quicker to OR during regular work hours)
  - Demarest, J Trauma, 1999 (OH - responded more quickly than IH)

Structure-Process-Outcome

- More complicated than we originally thought!
- Organizational theory
  - People (management and employees) and organizational arrangements - key determinants of quality and performance
- Leadership, human capital, information management systems, and group dynamics (culture, incentive systems)
- It's all about the people!

Glickman, Int J Qual Health Care, 2007
"Get the right patient to the right place at the right time"

Trauma system Essential components
- Pre-hospital triage protocols
- Bypass of nearer, non-designated centers
- Inclusivity - all centers participate
- Trauma center designation process
- Interfacility transfer agreements
- System-wide quality assurance
- Region-wide trauma center coverage
- Number of trauma centers based on need
- Supported by legislation

Effect of regional trauma systems

10% reduction in mortality
Effect of trauma systems on motor vehicle crash mortality
Nathens, JAMA, 2000

<table>
<thead>
<tr>
<th>Legislation</th>
<th>Effect on crash mortality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regional trauma system</td>
<td>↓ 9%</td>
</tr>
<tr>
<td>Primary restraint laws</td>
<td>↓ 13%</td>
</tr>
<tr>
<td>Secondary restraint laws</td>
<td>↓ 3%</td>
</tr>
<tr>
<td>65 mph (vs 55 mph) speed limit</td>
<td>↑ 7%</td>
</tr>
<tr>
<td>Administrative revocation laws</td>
<td>↓ 5%</td>
</tr>
</tbody>
</table>

Inclusive vs Exclusive Systems

- **Level I/II**
  - Provides definitive care - urban
  - Exclusive system

- **Level III/IV/V**
  - Initial care of major trauma – rural
  - All centers involved in quality assurance
  - Easier identification of need to transfer to higher level center
  - Decentralized in case of disasters

MacKenzie et al., JAMA, 2003;289:1515-1522
Inclusive Trauma Systems: Do They Improve Triage or Outcomes of the Severely Injured?

Challenges to trauma system design

- Too much access
- Too little access

Geographic variations in MVC-mortality: Baker et al, 1987

Population density (persons/sq mile)  MVC mortality (per 100,000 persons)

Esmerelda, NV versus Manhattan, NY
Overcoming the challenges of geography: Access to trauma centre care in Ontario

Ontario, Canada

- Twice the size of Texas: 416,000 sq mi
- 13 million people
- 90% rural
  - 19% of the population >60 miles from a specialist
- Very crude system
  - 9 adult trauma centers
  - No coordination
  - No standards for EDs & no lower level centers
  - No system PI
Do we have a problem?

- How do we convince policy makers we need to adopt an organized system of trauma care?
  - "No problem"
  - "Everything works fine."
  - "No one is dying"
  - No data = no problem

Does lack of timely access affect mortality?

i.e. Is there a need for change?

Mean - 6 hrs; 90% percentile - 11 hrs
Results

34% 66%

11,398 patients

What is the excess mortality associated with undertriage?

20% greater risk of dying if first transported to a non-trauma center.

Half of all patients died almost three hours after arrival at a non-trauma center.

Average time to make the phone call to transfer a patient: 2 hrs from arrival.
18% of all deaths occur in ED’s before transfer.

Hospital resources

- Physical resources
  - Intensive care unit
  - CT scanner
- Human resources
  - General surgery
  - Orthopedic surgery
  - ED staffing
    - Emergency medicine
    - Mixed
    - Family medicine

Hospital resource availability

<table>
<thead>
<tr>
<th>Resource Availability</th>
<th>General Surgery</th>
<th>Orthopedic Surgery</th>
<th>ED Staffing</th>
<th>ICU</th>
<th>CT Scanner</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rich (22%)</td>
<td>Yes</td>
<td>Yes</td>
<td>Emergency Medicine</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Variable (59%)</td>
<td>Yes/No</td>
<td>Yes/No</td>
<td>Mixed</td>
<td>Yes/No</td>
<td>Yes/No</td>
</tr>
<tr>
<td>Limited (19%)</td>
<td>No</td>
<td>No</td>
<td>Family Medicine</td>
<td>No</td>
<td>No</td>
</tr>
</tbody>
</table>
ED LOS and centre type

- Median ED length of stay:
  - Resource rich: 3.4 hrs
  - Resource variable: 2.7 hrs
  - Resource limited: 2.5 hrs

Patients in resource rich ED’s had twice the risk of a prolonged ED LOS compared to resource limited centers.

Prolonged ED LOS and resources

- Adjusted OR (95% CI)*
  - ED - Family medicine (ref): 2.0 (1.5 - 2.8)
  - ED - Mixed: 1.4 (1.0 - 2.0)

*Adjusted for sex, age, comorbidities, mechanism, ISS, severe injury by body region, year and individual resources.
Access to trauma care in Toronto: the tale of triage gone awry
Toronto EMS field trauma triage criteria

- If any criteria are met and transport times < 30 min, direct to trauma center
- Paraplegia/quadriplegia
- Penetrating trauma to the head, neck, trunk or groin
- GCS < 10

OR
- Any 2 of the following:
  - GCS 11-14
  - SBP < 80
  - RR < 10 or RR > 24
  - HR < 50 or HR > 120

What is the compliance with FTT criteria?

- Geocoded scene of injury
- Road network data used to calculate driving distances from the scene to:

Scene Closest hospital Closest trauma center

Differential distance

Results

- ~900 patients meeting Toronto field triage criteria
- Only half (53%) were transported to a trauma center
Transport destination by Toronto neighborhood

Patient characteristics

<table>
<thead>
<tr>
<th></th>
<th>Trauma center</th>
<th>Non-trauma center</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n = 477</td>
<td>n = 421</td>
</tr>
<tr>
<td>Male</td>
<td>76%</td>
<td>54%</td>
</tr>
<tr>
<td>Age ≥ 65</td>
<td>18%</td>
<td>51%</td>
</tr>
<tr>
<td>Mechanism</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fall</td>
<td>30%</td>
<td>66%</td>
</tr>
<tr>
<td>MVC</td>
<td>26%</td>
<td>7%</td>
</tr>
<tr>
<td>Stab wound</td>
<td>16%</td>
<td>3%</td>
</tr>
<tr>
<td>Gunshot wound</td>
<td>14%</td>
<td>1%</td>
</tr>
<tr>
<td>Other</td>
<td>12%</td>
<td>17%</td>
</tr>
</tbody>
</table>

p < 0.05

Patient physiology

<table>
<thead>
<tr>
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<tbody>
<tr>
<td></td>
<td>n = 477</td>
<td>n = 421</td>
</tr>
<tr>
<td>GCS*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>14%</td>
<td>13%</td>
</tr>
<tr>
<td>11-14</td>
<td>17%</td>
<td>26%</td>
</tr>
<tr>
<td>3-10</td>
<td>67%</td>
<td>60%</td>
</tr>
<tr>
<td>SBP &lt; 80</td>
<td>23%</td>
<td>24%</td>
</tr>
<tr>
<td>Abnormal RR*</td>
<td>45%</td>
<td>22%</td>
</tr>
<tr>
<td>Abnormal HR*</td>
<td>38%</td>
<td>25%</td>
</tr>
</tbody>
</table>
Differential distance from trauma center

<table>
<thead>
<tr>
<th></th>
<th>Trauma center</th>
<th>Non-trauma center</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 – 1.5 mi</td>
<td>69%</td>
<td>31%</td>
</tr>
<tr>
<td>1.5 - 3 mi</td>
<td>49%</td>
<td>51%</td>
</tr>
<tr>
<td>3 - 6 mi</td>
<td>45%</td>
<td>55%</td>
</tr>
<tr>
<td>&gt; 6 mi</td>
<td>51%</td>
<td>49%</td>
</tr>
</tbody>
</table>

Who is being disadvantaged?

Odds Ratio (95%CI)

- Female: 0.65 (0.45 – 0.94)
- Fall (vs MVC): 0.14 (0.08 – 0.23)
- Age ≥ 65 (vs 16-24): 0.28 (0.16 – 0.50)
Reflections

- We have made significant progress with trauma care.
- Currently THE model for emergency care in the United States
  - ...but there is always more to do
- Take advantage of your expertise and position
  - Ask a lot of questions
    - Why do we do this?
    - Is there a better/different way?
  - Learn how to advocate
  - Work with and not against decision makers
- Aim for constant, gentle pressure and slow, incremental change
Special thanks to:

- Ronald Maier
- Jerry Jurkovich
- Fred Rivara
- Michael Copass
- & the HMC Trauma Team!