Post-Traumatic Venous Thromboembolism in 2016

M. Margaret Knudson MD, FACS
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Case Presentation: SFGH 2016

- 24 year old involved in MCC
- Presented to ED with mild hypotension
- Complaining only of severe leg pain
- Underwent full trauma evaluation
- Ortho anxious to “fix the broken bone”
Initial “Pan Scan”
Pre-operative Duplex Scan
Case Presentation Continued

• Decision made to perform immediate orthopedic procedure
• Patient did well during surgery
• Developed **acute desaturation** in the recovery area
• **PaO2= 40 mmHg!**
Immediate Post-Op CTA
Historical Perspectives

“A study of protocols of 9,882 postmortem exams including death from injury...in the traumatic group embolisms were found in 61 cases (3.8%) and in the non-traumatic group in 222 cases (2.6%). Statistically, this appears to be a significant difference.”

J.S. McCartney, 1934
Historical Perspectives

- 124 trauma patients: venograms
- Fracture patients: 35% venous thrombosis
- Thrombus found within 24 hours of injury
- Both injured/uninjured extremity
- 2/3rds with DVT-asymptomatic

*Freeark et al, 1967*
INCIDENCE: OCCULT DVT

- 349 injured patients: screening venography*
- None receiving prophylaxis
- Proximal DVT rate: 18%
- PE rate: 2% (43% mortality!!)

*Geerts et al, NEJM 1994
Current Data on Surveillance Bias

- 17 Trauma Centers involved in “CLOTT”
- Incidence of Clinically recognized DVT: 1-2%
- Routine Surveillance with Duplex
- **Occult DVT: 9%**
- Should they all be treated???
- Quality measure tied to reimbursement
Incidence of Occult PE after Trauma

- 90 consecutive patients; ISS $\geq 9$
- Asymptomatic; no DVT
- Chest CT: between 3-7 days
- **22 had clot on CT; 4 were major!**
- 30% were receiving prophylaxis

Schultz and Brasel al J Trauma 2004
THROMBOEMBOLISM AFTER TRAUMA

AN ANALYSIS OF 1602 EPISODES FROM THE ACS NATIONAL TRAUMA DATA BANK

Annals of Surgery 2004

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The University of California, San Francisco
RESULTS

- 450,375 patients included
- 84% blunt injuries
- 31% ISS>10
- 998 pts: DVT (0.36%)
- 522 pts: PE (0.13%)
- 82 pts: both DVT/PE
- PE mortality: 18.7%
# RISK FACTOR ANALYSIS

<table>
<thead>
<tr>
<th>Risk Factor</th>
<th>Odds Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shock on admission (BP &lt; 90 mHg)</td>
<td>1.95</td>
</tr>
<tr>
<td>Age ≥ 40 yrs.</td>
<td>2.29</td>
</tr>
<tr>
<td>Head injury (AIS ≥ 3)</td>
<td>2.59</td>
</tr>
<tr>
<td>Pelvic fracture</td>
<td>2.93</td>
</tr>
<tr>
<td>Lower extremity fracture</td>
<td>3.16</td>
</tr>
<tr>
<td>Spinal cord injury with paralysis</td>
<td>3.39</td>
</tr>
</tbody>
</table>


p < .0001 for all factors
## RISK FACTOR ANALYSIS (CONT’)

<table>
<thead>
<tr>
<th>Risk Factor</th>
<th>Odds Ratio</th>
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</thead>
<tbody>
<tr>
<td>Major surgical procedure</td>
<td>4.32</td>
</tr>
<tr>
<td>Venous injury</td>
<td>7.93</td>
</tr>
<tr>
<td>Ventilator days &gt; 3</td>
<td>10.62</td>
</tr>
</tbody>
</table>

$p < .0001$ for all factors
## Multivariate Analysis

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<th>Risk Factor</th>
<th>Odds Ratio</th>
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<tr>
<td>Head injury (AIS ≥ 3)</td>
<td>1.24</td>
</tr>
<tr>
<td>Major operative procedure</td>
<td>1.53</td>
</tr>
<tr>
<td>Lower extremity fracture (AIS ≥ 3)</td>
<td>1.92</td>
</tr>
<tr>
<td>Age ≥ 40 years</td>
<td>2.01</td>
</tr>
<tr>
<td>Venous injury</td>
<td>3.56</td>
</tr>
<tr>
<td>Ventilator days &gt; 3</td>
<td>8.08</td>
</tr>
</tbody>
</table>

$p ≤ 0.0125$ for all factors
VENA CAVA FILTERS

- Procedure code: “IVC plication”
- 3,883 patients
- 86%: prophylaxis (no VTE)
- PE rate in filter group: 4.7%
- 410 patients: no risk factors
- Permanent IVC filters
CONCLUSIONS

• Clinically significant VTE rates: low
• 90% VTE pts. have at least 1 risk factor
• VTE risk- varies with each factor
• Role of IVC filters: re-examined
PROPOSED ALGORITHM

Injured Patient

High Risk Factor
\((OR \text{ for } VTE = 2-3)\)
- Age \(\geq 40\)
- Pelvic fx
- Lower extremity fx
- Shock
- Spinal cord injury
- Head trauma \((AIS \geq 3)\)

Very High Risk Factor
\((OR \text{ for } VTE = 4-10)\)
- Major operative procedure
- Venous injury
- Ventilator days > 3
- 2 or more high risk factors

Contraindication for heparin?

No
- LMWH*

Yes
- LMWH* and mechanical compression

Mechanical compression and serial CFD OR temporary IVC filter

*Prophylactic dose
Knudson’s Trauma Triad

Paralysis
Immobilization
Stasis

Venous Trauma
Fractures
Endothelial Damage

Hypercoagulability

Multiple Transfusions
Severe Injuries
Practice Patterns VTE Prophylaxis in Trauma

- 315 patients: 11% VTE
- Early prophylaxis: 4% risk
- Prophylaxis after 4 days: 3 times greater!
Filter Fever!
Prophylactic Vena Cava Filters?

- Problems:
  - Recurrent PE: 3%
  - No protection against DVT
  - 10%: caval thrombosis
  - permanence: leg edema
  - migration/IVC perforation
  - timing: 6% PE within 24 hours
Retrievable Filters: “NOT”

- May be retrieved within 5 days
- May be left in place: 30 days?
- Solution for high risk patients?
- Leads to 3-fold increase use
- AAST study: >400 patients
- Only 22% were retrieved!
- $100,000/ PE prevented

Antevil J Trauma 2006
Karmy-Jones J Trauma 2007
3738 POST-TRAUMATIC PULMONARY EMBOLI

A NEW LOOK AT AN OLD DISEASE

M.M. Knudson, D. Gomez, B. Haas, MJ Cohen, AB Nathens

U. California San Francisco, U. Toronto
Historical Perspective: Pulmonary Emboli

- Recognized post-injury complication: 1934*
- Mortality rates: **25-50%**
- Clinical presentation: acute hypoxia, collapse
- Diagnostic study: **autopsy**

*McCartney, Am J Pathology*
Current Perspective: PE

- “Potentially preventable” complication
- Clinical Presentation: unexplained drop $\text{PaO}_2$
- Often incidental finding: multidector CT scan
- Quality indicator: CMS, JACHO, AHRQ
Purpose

- To describe the current incidence of pulmonary embolism following trauma in the United States
- To determine the PE-attributable mortality
Major Hypotheses

1. Risk factors for PE-different from DVT
2. PE-incidence rates are increasing
3. PE-attributable mortality is decreasing
Methods

- **ACS/NTDB**
- Adult patients: Level I/II centers*
- **Current** version: 2007-2009
- **Historical** comparison: 1994-2001 (version 1)
- **Comparison**: centers contributing to both
- Hierarchical logistic regression models: risk factors, mortality

*(centers reporting at least one complication)*
Results: Current NTDB Cohort

- 888,652 Patients; 326 Trauma Centers
- Overall mortality: 1.8%
- 9,398 episodes: DVT (1.06%)
- 3,738 episodes: PE (0.42%)
- Only 20% with PE had DVT reported
## Risk Factor Analysis

<table>
<thead>
<tr>
<th>Risk Factor</th>
<th>DVT (9,398); OR (95% CI)</th>
<th>PE (3,738); OR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Severe TBI</td>
<td>1.34 (1.20-1.48)*</td>
<td>0.87 (0.73-1.04)</td>
</tr>
<tr>
<td>Ventilator Days &gt;3</td>
<td>5.31 (5.05-5.60)*</td>
<td>3.81 (3.48-4.18)</td>
</tr>
<tr>
<td>Severe Chest Injury (AIS≥3)</td>
<td>1.07 (1.01-1.12)</td>
<td>1.42 (1.30-1.55)*</td>
</tr>
<tr>
<td>Lower Ext. Fracture (AIS≥3)</td>
<td>1.53 (1.45-1.62)</td>
<td>1.81 (1.67-1.97)</td>
</tr>
<tr>
<td>Pelvic Fracture</td>
<td>1.32 (1.24-1.41)</td>
<td>1.19 (1.08-1.32)</td>
</tr>
<tr>
<td>Spine Injury (AIS≥4)</td>
<td>1.58 (1.42-1.75)</td>
<td>1.91 (1.61-2.27)</td>
</tr>
<tr>
<td>Shock (SBP≤90)</td>
<td>1.23 (1.14-1.34)</td>
<td>1.19 (1.04-1.36)</td>
</tr>
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*Knudson, et al., Annals of Surgery, 2004*
Results: IVC Filters

- 16,809 patients: 1.9% of total population
- 13,201: Prophylactic
- Center clustering: 0%-10.6%
# Changes over Time: PE

<table>
<thead>
<tr>
<th></th>
<th>Historical Number (%)</th>
<th>Adjusted OR (95% CI)</th>
<th>Current Number (%)</th>
<th>Adjusted OR (95% CI)</th>
</tr>
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<tbody>
<tr>
<td><strong>PE Rate</strong></td>
<td>499 (0.21%)</td>
<td></td>
<td>890 (0.49%)</td>
<td>p&lt;0.01</td>
</tr>
<tr>
<td><strong>Mortality-PE</strong></td>
<td>73 (15%)</td>
<td>4.05 (3.02-5.46)</td>
<td>111 (11%)</td>
<td>2.42 (1.91-3.06)</td>
</tr>
</tbody>
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Discussion: Potential Explanation

• 1. True increased incidence of PE
• 2. Better reporting in NTDB/ NTDS
• 3. “Sicker” patients in current cohort
• 4. Failure of VTE prophylactic measures
• 5. Improved methods of detection
Uncoupling DVT and PE

Severely Injured Patient
- Shock
- Coagulopathy

Protein C Depletion?

Hypercoagulable State

TBI
Fractures

Stasis
Venous Injury

DVT

Chest Injury

Inflammation

PE
PE rates versus Prophylactic IVC filters

PE rates

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Prophylactic IVC Filters

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<th>Current</th>
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<tr>
<td>IVC Filters</td>
<td>0.75%</td>
<td>1.5%</td>
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Conclusions

- **PE**: increasingly recognized post injury
- **PE**: decreased attributable mortality
- **PE**: may develop de novo
- **PE**: chest trauma/inflammation
- **PE**: may not be prevented by filters
Knudson’s Trauma Triad

Paralysis
Immobilization
Stasis
Endothelial damage
Venous trauma
Fractures

Hypercoagulability
Multiple transfusions
Severe injuries

Knudson, et al., J Trauma, 1994
POC Coagulation Monitoring

Thromb-elastograph
*(Haemoscope Corp.)*

Sonoclot
*(Sienco Inc.)*
Fibrinolysis Shutdown: New VTE Target?