Eastern Association for the Surgery of Trauma

Advanced Practitioners in Trauma Workshop
Hospital Complications in Trauma and Acute Care Surgery

January 15, 2015
Disney’s Contemporary Resort
Lake Buena Vista, Florida

Accreditation Statement
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**This workshop qualifies for Self-Assessment Credit.

American College of Surgeons
Division of Education
PE SXS/ Signs

- Dyspnea (79%)
- Tachypnea (57%)
- Pleuritic pain (47%)
- Leg edema, erythema, tenderness, palpable cord (47%)
- Cough/ hemoptysis (43%)

Incidence

900,000 PEs/ DVTs in USA in 2002.
Estimated 296,000 PE deaths:
7% treated, 34% sudden and fatal, and 59% undetected.

Stein PD. Am J Med 2007; 120: 871-879

Heit J. ASH Abstract 2005

762,000 PEs/ DVTs in EU in 2004

Throm Haemostas 2007; 98: 756
The high death rate from PE (exceeding acute MI!) and the high frequency of undiagnosed PE causing “sudden cardiac death” emphasize the need for improved preventive efforts.

Failure to institute prophylaxis is a much bigger problem with Medical Service patients than Surgical Service patients.

**Annual # At-Risk for VTE: US Hospitals**

- 7.7 million Medical Service inpatients
- 3.4 million Surgical Service inpatients
- Based upon ACCP guidelines for VTE prophylaxis

Case 1

- 21 yo F s/p MVC on 10/12 with pelvic fx and below-listed injuries
  - R distal radius fx
  - R ulnar styloid process fx
  - R displaced fx of third-fifth metacarpal shafts w/soft tissue swelling
  - R acetabulum fx
  - L iliac wing fx
  - L pubic body sagittal fx
  - R superior and inferior pubic rami fx
  - L inferior pubic rami fx
  - L open femoral shaft fx
Case 1

• ICU protocol: DVT screen every Wednesday found to have a **Soleal DVT day 4.** What is the best course of action
  – Lovenox therapeutic
  – Lovenox treatment
  – Heparin drip
  – IVC filter
  – fondaparinux

Case 2

• 55 yo male prolonged ICU stay after multiple injuries. Has left leg swelling. Doppler shows an acute DVT right common femoral
  – Lovenox therapeutic
  – Lovenox treatment
  – Heparin drip
  – IVC filter
  – fondaparinux

Case 2

• Heparin drip started; with 6 hours massive melena BP 80/palp HR 140
  – Then what?
Diagnostic investigations

If a patient presents with signs or symptoms of DVT, carry out the following to exclude other causes:

- an assessment of their general medical history and
- a physical examination.

If DVT is suspected, use the two-level DVT Wells score.

Diagnostic investigations

Wells score = DVT likely

Offer either:

- proximal leg vein ultrasound scan (within 4 hours of request), if negative, a D-dimer test or
- if proximal leg vein scan not available within 4 hours, D-dimer test and an interim 24-hour dose of a parenteral followed by proximal leg vein ultrasound within 24 hours of request

Repeat proximal leg vein ultrasound scan 6–8 days later for all patients with positive D-dimer test and negative proximal leg vein ultrasound scan.

Thromboembolism after trauma

AN ANALYSIS OF 1602 EPISODES FROM THE ACS NATIONAL TRAUMA DATA BANK
Annals of Surgery 2004

M. Margaret Knudson MD
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Linda Khau BA
Diane Morabito RN, MPH
Larisa S. Speetzen BA
The University of California, San Francisco
**VTE Risk Factor Analysis**

**Hypotheses:**
- Clinical incidence of VTE - relatively low
- Patients who would benefit from VTE prophylaxis could be clearly identified

**Methods**

Data source: NTDB (1994-2001)
Data analysis:
- Demographics
- Nature/severity of injuries
- Complications/outcomes
Survey: participating trauma centers
- VTE risk factors/protocols

**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

<table>
<thead>
<tr>
<th>Risk Factor</th>
<th>Odds Ratio</th>
</tr>
</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

<table>
<thead>
<tr>
<th>Risk Factor</th>
<th>Odds Ratio</th>
</tr>
</thead>
<tbody>
<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
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

IVC Filters: Is the long-term risk justified by the immediate benefit?

Indication

1. Contraindication to anticoagulation with DVT / PE
   GI bleed / Intracranial Hemorrhage
2. Failed anticoagulation with DVT / PE
3. Trauma patient at High risk for DVT / PE
4. High risk procedure for thromboembolism with history of venous thromboembolism
5. Patient with VTE at high risk secondary to location
   Free floating clot
Why?

<table>
<thead>
<tr>
<th>Year</th>
<th>Count</th>
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</thead>
<tbody>
<tr>
<td>1979</td>
<td></td>
</tr>
<tr>
<td>2000</td>
<td></td>
</tr>
<tr>
<td>2007</td>
<td>167000</td>
</tr>
<tr>
<td>2012</td>
<td>259000</td>
</tr>
</tbody>
</table>


Since 2005, the FDA has received 921 device adverse event reports involving IVC filters, of which 328 involved device migration, 146 involved embolizations (detachment of device components), 70 involved perforation of the IVC, and 56 involved filter fracture.

Short term Complications

- Insertion or deployment-related complication
  - Pneumothorax / Hemothorax
  - Wound hematoma / bleeding: 2.4-4.2%
  - Arterial injury
  - A-V fistula
  - Ulceration
- Placement
  - Vessel wall perforation / cardiac tamponade
  - Pulmonary embolus
  - Misplacement:
  - Incidence of 0.7-4.6%
  - ≤ 2.5% with cavography
Short term Complications

• Migration
  – Overall Incidence (>9mm) 2.9 to 12%
  – 1990’s: high incidence 48 -76%
  – 30% with old stainless steel Greenfield filters
  – 11% titanium GF filters with modified hooks


Long-term Complications

• Thrombosis at Insertion Site: 1.8% -24.7%
• Distal Deep Venous Thrombosis: 18% – 35.7%
• Filter
  – Thrombus: 3.1 to 11.4%
  – Angulation: 0.6%
  – Endothelialization: 1.9%


Long-term Complications

• IVC occlusion/thrombosis
  – Filter dependent:
    • GF: 1 - 9% (currently 3.6%)
    • Vena Teck: 4.5-24%
    • Simon Nitinol: 3.5%
  – 2% in General Population
  – 2.3 to 3.5% in Trauma Population

**Long-term Complications**

- Filter erosion or perforation of the IVC
  - GF 30%
  - Bird’s Nest 85-100%
  - Simon Nitinol 95%
- Filter migration
- Recurrent PE:
  - 2.5 to 7.7% reported incidence
  - Fatal Recurrent PE: 0-4.4%


**Breakthrough PE**

Permanent filters - Nonrandomized Case series

Permanent Filters
- 0 to 4.6% incidence

Removable Filters
- 0 to 1.9%

**PE Prophylaxis**

Among 1191 patients receiving filters for a variety of indications
  - 2% developed PE

In 385 trauma populations receiving IVC filters
  - 249 (65%) Prophylaxis purposes
    - PE in 2.5% of pts
  - 136 (35%) after a diagnosis of VTE
    - PE in 2.5% of pts
Breakthrough PE
permanent filters – randomized trials

Randomized Controlled Trials: PREPIC STUDY


- 400 pts
  - DVT with and without PE
  - Anticoagulation therapy (+3mm) +/- filter
  - 8 year Follow up

Prospective Randomized study comparing the clinical outcomes between inferior vena cava Greenfield and TrapEase filters.

- Prospective Randomized study - July 2006- Nov. 2008
- 156 patients
  - 84 Greenfield Filter (12 Fr. Introducer)
  - 72 TrapEase (6 Fr. Introducer)
- FU duplex : 12 month FU : Day 1, Week 1, q 3 mon x4, q6mon x2

<table>
<thead>
<tr>
<th>Indication</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>GI bleed</td>
<td>IVC thrombosis 5/72 (6.9 %)</td>
</tr>
<tr>
<td>DVT</td>
<td>Recurrent PE 4/72 (5.6 %)</td>
</tr>
<tr>
<td>Free floating Clot</td>
<td>Mortality 66/72 (42.3 %)</td>
</tr>
<tr>
<td>Failure of AC</td>
<td>PE 7/72 (6.9 %)</td>
</tr>
<tr>
<td>PE</td>
<td>No filter migration</td>
</tr>
<tr>
<td>Others</td>
<td>No access site Thrombosis</td>
</tr>
<tr>
<td></td>
<td>No replacement</td>
</tr>
<tr>
<td></td>
<td>No IVC perforation</td>
</tr>
</tbody>
</table>

Table III. Patients with inferior vena cava thrombus

<table>
<thead>
<tr>
<th>No</th>
<th>Age</th>
<th>Sex</th>
<th>Medical history</th>
<th>Indication for IVC</th>
<th>Time of onset</th>
<th>IVC-related complications</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>87</td>
<td>M</td>
<td>CHE, HX, Abnormal test results</td>
<td>IVC thrombosis</td>
<td>Day 1</td>
<td>DVT</td>
<td>Died (surgery)</td>
</tr>
<tr>
<td>2</td>
<td>77</td>
<td>M</td>
<td>CHE, HX, Abnormal test results</td>
<td>IVC thrombosis</td>
<td>Day 1</td>
<td>DVT, IVC</td>
<td>Alive</td>
</tr>
<tr>
<td>3</td>
<td>58</td>
<td>M</td>
<td>CHE, HX, Abnormal test results</td>
<td>Free floating Clot</td>
<td>Day 1</td>
<td>DVT</td>
<td>Alive</td>
</tr>
<tr>
<td>4</td>
<td>66</td>
<td>M</td>
<td>CHE, HX, Abnormal test results</td>
<td>Failure of AC</td>
<td>Day 1</td>
<td>DVT</td>
<td>Alive</td>
</tr>
<tr>
<td>5</td>
<td>62</td>
<td>M</td>
<td>CHE, HX, Abnormal test results</td>
<td>Recurrent PE</td>
<td>Day 1</td>
<td>DVT, IVC</td>
<td>Alive</td>
</tr>
</tbody>
</table>
Retrievable IVC filters


- 427 patients with retrievable filters
- 275 patients with permanent filters
- FU: 11.5 months
- PE occurred
  - 4.0% of retrievable filters
  - 4.7% of permanent filters
- 70% of retrievable filters were successfully removed
- 12 month FU: no PE post retrieval

Retrievable IVC filters


- 72 trauma patients with retrievable filters
  - Contraindications to retrieval 62.5%
  - Lost to FU 15.2%
  - Technical failure 2.8%
  - Died before retrieval 1.3%
Recurrent symptomatic versus thromboembolism (VTE), major bleeding and mortality at 3 months – summary of two meta-analyses in deep vein thrombosis and pulmonary embolism

<table>
<thead>
<tr>
<th></th>
<th>Low molecular weight heparin (%)</th>
<th>Unfractionated heparin (%)</th>
<th>OR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Deep vein thrombosis</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Recurrent VTE</td>
<td>86/1998 (4.3)</td>
<td>113/2021 (5.6)</td>
<td>0.75 (0.55–1.01)</td>
</tr>
<tr>
<td>Major Bleeding</td>
<td>30/2351 (1.3)</td>
<td>51/2401 (2.1)</td>
<td>0.60 (0.39–0.93)</td>
</tr>
<tr>
<td>Mortality</td>
<td>135/2108 (6.4)</td>
<td>172/2137 (8.0)</td>
<td>0.78 (0.62–0.99)</td>
</tr>
<tr>
<td><strong>Pulmonary embolism</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Recurrent VTE</td>
<td>30/988 (3.0)</td>
<td>39/895 (4.4)</td>
<td>0.68 (0.49–1.00)</td>
</tr>
<tr>
<td>Major Bleeding</td>
<td>14/1023 (1.4)</td>
<td>21/928 (2.3)</td>
<td>0.67 (0.36–1.27)</td>
</tr>
<tr>
<td>Mortality</td>
<td>46/988 (4.7)</td>
<td>55/895 (6.1)</td>
<td>0.77 (0.52–1.15)</td>
</tr>
</tbody>
</table>

Which of the following statement is false regarding DVTs

- Clinical diagnosis is very obvious
- Obese patients at higher risk
- Hip and knee replacement are high risk for developing DVT
- Optimal hydration is essential to prevent it
Case 3

- 66 yo male initially presenting for a crush and degloving injury to his left hand at work, no other trauma
- PMH: Hypercholesterolemia
- PSH: None
- Meds: Simvastatin
- All: NKDA
- Soc Hx: Denies EtOH, smoking

- HD 1 to OR for complex laceration repair, ORIF, and integra placement
- Initially on Lovenox for 2 days, then this was discontinued. Pt on ASA 325, statin, ancef
- Pt intermittently ambulatory but left hand in stockinette suspended from IV pole while in bed
- returned to OR Hd4 for debridement, Integra placement
- Kept in hospital for complex wound care

- HD 5 while walking had syncopal episode
- Apneic, cyanotic, unresponsive for 3 min
- BVM initiated, pulse ox 91%
- Awoke spontaneously and became appropriate
- c/o some pain in left lower chest
- SBP 100, HR 130s, RR 30s, sats 93% on 4L NC
- EKG sinus tach
- Troponin 0.4->1.22
Management of PE

- UFH gradually replaced by LMWH
- Similar efficacy and safety in sub-massive PE
- No difference in mortality between altepase and LMWH compared to LMWH alone (NEJM 2002)
- Thrombolytic therapy essential in massive PE (better identification of patients needed).
## Thrombolytic Therapy in PE

Subgroup analysis of trials that included major (hemodynamically unstable) pulmonary embolism compared with those that excluded patients with major pulmonary embolism.

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Trials that included patients with major PE</th>
<th>Trials that excluded patients with major PE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Lysis, n/N (%)</td>
<td>Heparin, n/N (%)</td>
</tr>
<tr>
<td>Recurrent PE or death</td>
<td>12/128 (9.4)</td>
<td>24/126 (19.0)</td>
</tr>
<tr>
<td>Recurrent PE</td>
<td>5/128 (5.6)</td>
<td>5/126 (7.9)</td>
</tr>
<tr>
<td>Death</td>
<td>8/128 (6.2)</td>
<td>16/126 (12.7)</td>
</tr>
<tr>
<td>Major bleeding</td>
<td>28/128 (22.0)</td>
<td>15/126 (11.9)</td>
</tr>
</tbody>
</table>


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## Incidence of Occult PE after Trauma

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

Schultz et al J Trauma 2004
Clostridium Difficile Infection
Early Identification and Treatment Strategies

Cassandra Winter, MPAS, PA-C
Trauma and Acute Care Surgery
UPMC Presbyterian
Pittsburgh, PA

Epidemiology

- Clostridium difficile (C diff) was identified as the causative organism in most cases of antibiotic-associated diarrhea in 1978

-Clostridium difficile: anaerobic, gram positive, spore forming, bacillus

Epidemiology

- The incidence of c diff is rising

- Death from CDI or CDI complications was about 4% in 2010

- An estimated $3.2 billion was spent on healthcare related to CDI in the US from 2000-2002.
Pathophysiology

• C. diff infection develops when intestinal flora is disrupted
• C. diff produces exotoxins, Toxin A & B
• Patients with known carriage to C. diff have higher levels of IgG antibodies to toxin A, decreasing their risk of infection

Epidemiology

• C. diff is easily transmitted via the fecal-oral route
• C. diff carriers are a significant source of environmental contamination, including in hospitals and long term care facilities

Epidemiology

• C. diff, NAP1/BI/027+: recent recognition of more virulent strain
Epidemiology

- Healthy population colonization is ~3-6%
- Hospitalization increases colonization rate up to 20-50%
- Colonization and new exposure put patients at risk for CDAD, more so than patients who present as known carriers
- Community acquired infections are also on the rise

Risk Factors

- Antibiotics
  - All antibiotics carry the risk of CDAD
  - Clindamycin, fluoroquinolones, penicillins, cephalosporins
  - Risk of CDAD highest during treatment and one month after
    - CDAD can develop as long as 3 months after therapy
  - Perioperative antibiotics

- Advancing Age
- H2 Blockers/PPIs
- Cancer/chemotherapy
- NPO/Tube feeding/elemental diets
Early Identification
• Symptoms
  - Watery diarrhea
  - Abdominal pain, lower, crampy
  - Nausea/vomiting
  - Fever

• Signs
  - Lower abdominal tenderness
  - Leukocytosis
  - Low grade fever
  - Unexplained WBC >15k, with risk factors, rule out c diff

Mild diarrhea  Sepsis/ Extremis

Early Identification: Fulminant C diff
• Symptoms
  - Severe abdominal pain
  - Watery diarrhea
  - Prolonged ileus can cause decreased diarrhea

• Signs
  - Diffuse abdominal tenderness
  - Abdominal distention
  - Tmax >38.5 ºC
  - Hypovolemia
  - Lactic acidosis
  - Hypoalbuminemia
  - Marked elevation in WBC
  - Up to 40K
  - Guarding, rigidity, absent BS, rebound tenderness= concern for perforation

Diagnosis: Lab Testing

<table>
<thead>
<tr>
<th>Test</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>C diff/cytotoxin assay</td>
<td>Excellent specificity (99%–100%)</td>
<td>Test results not available until after 48h</td>
</tr>
<tr>
<td></td>
<td>Sensitivity 76–90%</td>
<td>Requires tissue culture capacity</td>
</tr>
<tr>
<td>Immunassay for detection of toxin A &amp; B</td>
<td>Good specificity (85%–90%)</td>
<td>Reduced sensitivity (55%–85%) compared with cytotoxin assay</td>
</tr>
<tr>
<td></td>
<td>Test results available within 4 h</td>
<td></td>
</tr>
<tr>
<td>Stool culture to isolate C diff withYPN PCR for toxin genes</td>
<td>Research gold standard</td>
<td>Results not available for at least 72h (&lt;6 h lab)</td>
</tr>
<tr>
<td></td>
<td>Endotyping of strain for outbreak investigation</td>
<td>Labor intensive</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Non-specific carriers result in false positives (in diarrhetic stools processed)</td>
</tr>
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<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td>Sensitivity on par with cytotoxin assay</td>
<td>Specificity hindered by carrier state</td>
</tr>
<tr>
<td></td>
<td>Some day turn around time</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Empiric therapy does not hinder detection</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Specificity hindered by carrier state</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Test cost ($26-60/test)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Still on par with performing cytotoxin assay</td>
<td></td>
</tr>
<tr>
<td></td>
<td>required</td>
<td></td>
</tr>
</tbody>
</table>
Prevention of CDI

• Single use, disposable instruments
• Patient isolation
• Contact precautions
• Hand hygiene

Prevention

• Decrease environmental contamination
• Restriction of antimicrobials

Early Identification

• Imaging
  • KUB- normal, small bowel dilation, “thumb printing”- submucosal colonic edema, air fluid levels, free air
  • CT scan- pronounced colonic wall thickening
• Endoscopy = pseudomembranes
  • White-yellowish plaques, up to 2cm
  • Pathognomonic
Colonic wall thickening

"Thumb printing" - Submucosal edema

Toxic Megacolon
Clinical Practice Guidelines for Clostridium Difficile Infection in Adults

- 2010 Update by the Society for Healthcare Epidemiology of America (SHEA) and Infectious Disease Society of America (IDSA)
- Cohen et al.
- Posted on the CDC website for c diff

SHEA-IDSA Severity Scoring System

<table>
<thead>
<tr>
<th>Severity</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mild or moderate</td>
<td>WBC of 15K or lower &amp; Serum creatinine &lt;1.5 times pre-morbid level</td>
</tr>
<tr>
<td>Severe</td>
<td>WBC of 15K or higher or Serum creatinine &gt;1.5 times the pre-morbid level</td>
</tr>
<tr>
<td>Severe, complicated</td>
<td>Hypotension or shock, ileus, megacolon</td>
</tr>
</tbody>
</table>
### ACG Scoring System

<table>
<thead>
<tr>
<th>Severity</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mild</td>
<td>Diarrhea</td>
</tr>
<tr>
<td>Moderate</td>
<td>Diarrhea plus any additional signs or symptoms not meeting severe or complicated criteria</td>
</tr>
<tr>
<td>Severe</td>
<td>Any two of the following:</td>
</tr>
<tr>
<td></td>
<td>- WBC $\geq 15,000$ cells/mm$^3$</td>
</tr>
<tr>
<td></td>
<td>- Serum albumin $&lt; 3$ g/dL</td>
</tr>
<tr>
<td></td>
<td>- Abdominal tenderness</td>
</tr>
</tbody>
</table>

### Complicated

<table>
<thead>
<tr>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Admission to ICU for CDI</td>
</tr>
<tr>
<td>Hypotension with or without required use of vasopressors</td>
</tr>
<tr>
<td>Fever $\geq 38.5 ^\circ$</td>
</tr>
<tr>
<td>Severe or significant abdominal distention</td>
</tr>
<tr>
<td>Mental status changes</td>
</tr>
<tr>
<td>WBC $\geq 35,000$ cells/mm$^3$</td>
</tr>
<tr>
<td>Serum lactate levels greater than $2.2$ mmol/Liter</td>
</tr>
<tr>
<td>End organ failure (Mechanical ventilation, Renal failure, etc)</td>
</tr>
</tbody>
</table>
Treatment Strategies

- **Supportive Care**
  - IV fluid resuscitation
  - Management of electrolyte disturbances
  - Pharmacologic DVT prophylaxis
  - Continue oral or enteral feeding if no concern for ileus

- **Operative intervention**
  - Monitor patients closely for deterioration
  - Serum lactate >5 and WBC >50,000 associated with increased mortality

Metronidazole vs Vancomycin

- **Metronidazole**
  - Effective as intravenous or enteral form
  - Does not reach colon at effective MIC unless diarrhea
  - Both dosing regimens dependent upon GI motility

- **Vancomycin**
  - Intravenous not effective
  - Enteral (oral, tube, rectal) reaches colon effectively
  - MIC in both diarrheal and non-diarrheal stool

ACG Severity Scoring and Treatment

<table>
<thead>
<tr>
<th>Severity</th>
<th>Criteria</th>
<th>Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mild</td>
<td>Diarrhea</td>
<td>Metronidazole 500mg PO TID</td>
</tr>
<tr>
<td>Moderate</td>
<td>Diarrhea plus any additional signs or symptoms not meeting severe or complicated criteria</td>
<td>Metronidazole 500mg PO TID</td>
</tr>
<tr>
<td>Severe</td>
<td>Any two of the following: - WBC &gt; 15000 cells/mm³ - Serum albumin &lt; 3 g/dL - Abdominal tenderness</td>
<td>Vancomycin 125mg PO QID</td>
</tr>
</tbody>
</table>
### ACG Severity Scoring and Treatment

<table>
<thead>
<tr>
<th>Complicated</th>
<th>Any one of the following:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>- Admission to ICU for CDI</td>
</tr>
<tr>
<td></td>
<td>- Hypotension with or without required use of vasopressors</td>
</tr>
<tr>
<td></td>
<td>- Fever ≥38.5°C</td>
</tr>
<tr>
<td></td>
<td>- Ileus or significant abdominal distention</td>
</tr>
<tr>
<td></td>
<td>- Mental status changes</td>
</tr>
<tr>
<td></td>
<td>- WBC ≥35,000 cells/mm³</td>
</tr>
<tr>
<td></td>
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</tr>
<tr>
<td></td>
<td>- End organ failure (mech. ventilation, renal failure, etc)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Metronidazole 500 mg IV TID + Vancomycin 125 mg PO QID</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Vancomycin 500 mg in 500 mL saline as enema QID (if ileus or distended) + SURGICAL CONSULTATION</td>
</tr>
</tbody>
</table>

### Clinical Practice Guidelines for Clostridium Difficile Infection in Adults

- Probiotics
- Avoid antidiarrheal or antiperistaltic meds acutely
- No evidence to suggest treating asymptomatic carriers
- No test of cure warranted

### Treatment Strategies

- **Recurrent CDI**
  - 25% rate of reoccurrence in treated patients
  - Increased rate after first reoccurrence
  - Symptoms similar or worse than 1st episode
  - Risk factors: >65 y.o., ongoing antibiotic tx for primary infection, multiple comorbidities, immunosuppression
Treatment strategies- Recurrent CDI

- 1st Recurrence: Vancomycin
- 2nd Recurrence: Vancomycin 7 week taper
- 3rd Recurrence: Fecal Microbiota Therapy

Fecal Microbiota Transplant (FMT)

- Recommended treatment option for patients with multiple episodes of RCDI
- First documented case in 1958, 4 patients with pseudomembranous colitis
  - Sx resolved in hours
- Methods of administration: Nasogastric tube, colonoscopy, enemas

Duodenal Infusion of Donor Feces for Recurrent Clostridium difficile


**Fecal Microbiota Transplant (FMT)**

- Since 2011, ~325 case reports with an average cure rate of 91%
- Universal donors or patient-identified donors - rigorous stool testing
- Restores healthy intestinal flora similar to donor
- More RCTs are needed to confirm its safety and efficacy

**Fidaxomicin**

- Approved in 2011
- Macrocyclic antibiotic, bactericidal
- Dose: 200mg po BID x 10 days
- Activity against c diff, most staphylococci and enterococci
- Does not cover gram negatives or fungi
- Drawback: $$$

**Fidaxomicin vs Vancomycin**

- Non-inferior to Vancomycin for cure rate
- Lower reoccurrence rate
“Guidelines for Diagnosis, Treatment, and Prevention of Clostridium Difficile Infections”

**Conclusions**
- If a patient has a strong pre-test suspicion for CDI, begin appropriate therapy
- Inciting antibiotic should be stopped if possible
- CT scan of the abdomen is recommended for patients with complicated disease

**Management of comorbidities with CDI**

**Inflammatory bowel disease (IBD) patients**
- Any patient admitted with IBD flare should be tested for CDI
- Risk factors: ongoing immunosuppression, colonic inflammation, severe underlying dx
- Steroid use increases risk of CDI 3-fold, and also increases mortality
- Patients with ileostomy or ileoanal pouch can also develop CDI
- If sx severe, begin CDI treatment prior to test results

**Immunosuppressed patients**
- Cancer, chemotherapy, steroid use, organ transplant, cirrhosis
- Increased risk for CDI - new diarrhea= testing

**Pregnant/peripartum women**
- Any new diarrhea= testing
- One series noted high fetal and maternal mortality, with 5/10 patients developed toxic megacolon
- Vancomycin= drug of choice
Treatment Strategies: Surgery

- EAST Guidelines, 2014, review of 32 studies

  Journal of Trauma and Acute Care Surgery:
  June 2014 - Volume 76 - Issue 6 - p. 1484-1489
  doi: 10.1097/TA.0000000000000522

  Timing and type of surgical treatment of Clostridium difficile-associated disease: A practice management guideline from the Eastern Association for the Surgery of Trauma

  Kesten, Paula MD; Satyapal, Catherine G., MD; Sears, Lennex M.D; Keat, Elliott E., MD; Johnson, Randy B., MD; Bohigian, K. Peter, MD; Makhoul, Tony M. MD; Scullin, David R., MD; Mair, Brian L., MD; Sasson, Patricia M., MD; Bushing, Alyse R., MD; Bax, Theresa N., MD

  • EAST Guidelines

  • 1. Timing of surgical intervention
    • Early surgery, prior to shock or organ failure, is associated with decreased mortality
    • Typically between 3-5 days after presentation
    • Observe patients for early signs of hemodynamic instability: decreased arterial pressures, decreasing urine output
    • Peritonitis and bowel perforation is associated with increased post op mortality

  • EAST Guidelines

  • 2. Type of operation
    • Total abdominal colectomy (TAC) or subtotal colectomy
    • Partial colectomy
    • TAC is associated with decreased mortality and recommended for treatment of fulminant CDI
    • Loop ileostomy with colonic lavage is likely to lead to decreased risk of mortality compared to TAC
      • Directly lavage the colon with vancomycin
      • Post op vancomycin enemas
Surgery and CDI

• High mortality rate associated with colectomy

• Consult surgery early with severe and worsening disease

• Loop ileostomy- treat underlying infection without colon removal
  • Decreased mortality.
Summary

- Classify the severity of disease and begin appropriate treatment
- Consult surgery early
- Escalate treatment if clinically worsening
- High rate of reoccurrence
- Prevention and infection control

Case presentation

- 76 year old male h/o ESRD on HD, CAD s/p CABG, A-fib, OSA, and prior episode of c diff infection 1 month ago, presented to local ED c/o abdominal pain and diarrhea from a rehab facility.
  - Hypotensive on arrival, responded to IVF
  - Mild LLQ tenderness on exam
  - Labs - Albumin 2.4, lactate 3.4, WBC 17
  - Initial CT a/p - pan colitis
  - Started on metronidazole IV and oral Vancomycin
  - Surgery consulted

Case presentation

- HD #2: Hypotensive, WBC increased to 24k.
  - Transferred to tertiary care center
  - Upon arrival- hypotensive, peritonitic on exam- Taken emergently to the OR: Laparoscopic lysis of adhesions, creation of loop ileostomy with colonic lavage
    - ICU post op
    - Metronidazole IV, Vancomycin enemas
    - Required ongoing vent support and vasopressors
  - Post op course complicated by evisceration on POD #11- revision of loop ileostomy
  - Ongoing ICU management for acute respiratory failure and CHF
References

- Cohen, Stuart, et al. “Clinical Practice Guidelines for Clostridium Difficile infection in Adults: 2010 Update by the Society for Healthcare Epidemiology of America (SHEA) and the Infectious Disease Society of America (IDSA)” Infection Control and Hospital Epidemiology. 31. 2010: 431-455.
Disclosure Statement

• I, Gary T. Marshall, MD, have no financial or commercial interests in the material presented.

Learning Objectives

• Learn to recognize and diagnose delirium
• Understand the incidence and impact of delirium
• Identify risk factors for delirium
• Learn to employ preventative and non-pharmacologic interventions for delirium
• Discuss pharmacologic strategies for the treatment of delirium and its symptoms
What is delirium?

Definition

- Delirium is a transient, reversible syndrome of impairment of consciousness, attention, and perception in the setting of a medical condition that is acute and fluctuating.

Key Features of Delirium

- Disturbance of consciousness; reduced clarity of awareness of the environment, with reduced ability to focus, sustain, or shift attention
- Change in cognition such as impairment in memory or problem-solving or a perceptual disturbance, such as hallucinations
- Onset of hours to days, and tendency to fluctuate.
- Behavior may be either overactive or underactive, and sleep is often disturbed
- Thinking is slow and muddled but the content is often complex.
Differences between Delirium and Dementia

<table>
<thead>
<tr>
<th>Feature</th>
<th>Delirium</th>
<th>Dementia</th>
</tr>
</thead>
<tbody>
<tr>
<td>Onset</td>
<td>Sudden</td>
<td>Slow and gradual</td>
</tr>
<tr>
<td>Duration</td>
<td>Days to weeks</td>
<td>Permanent</td>
</tr>
<tr>
<td>Cause</td>
<td>Almost always another condition</td>
<td>Usually a chronic brain disorder</td>
</tr>
<tr>
<td>Course</td>
<td>Reversible</td>
<td>Progressive</td>
</tr>
<tr>
<td>Attention</td>
<td>Greatly impaired</td>
<td>Unimpaired until severe</td>
</tr>
<tr>
<td>Level of Consciousness</td>
<td>Varibly impaired</td>
<td>Unimpaired until severe</td>
</tr>
<tr>
<td>Orientation</td>
<td>Varies</td>
<td>Impaired</td>
</tr>
<tr>
<td>Use of Language</td>
<td>Slow, incoherent, and inappropriate</td>
<td>Occasional difficulty in word finding</td>
</tr>
<tr>
<td>Memory</td>
<td>Varies</td>
<td>Lost, especially short-term</td>
</tr>
</tbody>
</table>

What is the impact of delirium?

- Reported rates range from 5 to >50%
- Rates vary by surgical procedure
  - <5% following cataract surgery
  - 4-15% for elective hip surgery
  - 19-44% for emergency hip surgery
  - 30-50% for aortic surgery
Effects on postoperative outcomes

• Higher complication rates
• Higher probability of discharge to a nursing home
• Poorer functional outcome with a decline in basic activities of daily living at 1 and 12 months
• Increased mortality at 6 and 12 months
• Reduced cognitive function

Financial Burden

• $164 billion annually
• Significant increase in cost of hospitalization
• $50,100 for patients with delirium
• $31,600 in patients without
• Doubled length of stay in a study of patients undergoing non-orthopedic operations

What are the risk factors and causes?
Etiology

• Thought to be due to under-activity of cholinergic system coupled with excessive dopaminergic activity
• Delirium is the end result of a complex interaction between predisposing factors and precipitating factors

Predisposing Factors

• Advanced age
• Underlying cognitive impairment
• Functional impairment
• Coexisting medical comorbidities
• Psychotropic medications
• Alcohol abuse
• Sensory impairment
• Immobility

Precipitating Factors

• Infection
• Medications
• Hypoxemia
• Dehydration
• Sensory deprivation
• Electrolyte abnormalities
• Unfamiliar environment
• Malnutrition
• Surgery
• Neurologic events
• Sleep deprivation or disruption
• Use of physical restraints
• Use of a bladder catheter
Medications Associated with Delirium

<table>
<thead>
<tr>
<th>Drug Class</th>
<th>Drug Types</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anticholinergic</td>
<td>H1 Blocker, Phentolamine</td>
<td>diphenhydramine, meclizine</td>
</tr>
<tr>
<td>Antidepressant</td>
<td>Triyclics, SSRIs, Antipsychotics</td>
<td>imipramine, desipramine</td>
</tr>
<tr>
<td>Sedative</td>
<td>Benzodiazepines</td>
<td>alprazolam, diazepam</td>
</tr>
<tr>
<td>Antipsychotics</td>
<td>SSRIs, Opioids, Inotropes</td>
<td>clozapine, olanzapine</td>
</tr>
<tr>
<td>Antidepressant</td>
<td>Anticholinergic, Antipsychotics</td>
<td>amitriptyline, nortriptyline</td>
</tr>
<tr>
<td>Anxiolytics</td>
<td>Benzodiazepines</td>
<td>alprazolam, diazepam</td>
</tr>
<tr>
<td>Antiinflammatory</td>
<td>NSAIDs, Corticosteroids</td>
<td>aspirin, hydrocortisone</td>
</tr>
<tr>
<td>Antiinflammatory</td>
<td>ANTs, ACE inhibitors</td>
<td>propranolol, metoprolol</td>
</tr>
<tr>
<td>Antiinflammatory</td>
<td>Betablockers, ACE inhibitors</td>
<td>propranolol, metoprolol</td>
</tr>
<tr>
<td>Antiinflammatory</td>
<td>Beta blockers, Ca channel blockers</td>
<td>amlodipine, nifedipine</td>
</tr>
<tr>
<td>Antibiotics</td>
<td>Quinolones, Macrolides</td>
<td>levofloxacin, ciprofloxacin</td>
</tr>
<tr>
<td>Anticonvulsants</td>
<td>Barbirates</td>
<td>phenobarbital</td>
</tr>
</tbody>
</table>

Medications Associated with Delirium

<table>
<thead>
<tr>
<th>Preoperative</th>
<th>Intraoperative</th>
<th>Postoperative</th>
</tr>
</thead>
<tbody>
<tr>
<td>Antipsychotics</td>
<td>Anticholinergers, Opioids (dose dependent)</td>
<td>Opioids (dose dependent)</td>
</tr>
<tr>
<td>SSRIs</td>
<td>Fentanyl (dose dependent)</td>
<td>Sedatives (dose dependent)</td>
</tr>
<tr>
<td>Antidepressants</td>
<td>Benzodiazepines (dose dependent)</td>
<td>Inotropes</td>
</tr>
<tr>
<td>Benzodiazepines</td>
<td>Inotropes</td>
<td>Statins</td>
</tr>
</tbody>
</table>

Interplay of Predisposing and Precipitating Events

- High vulnerability to delirium
- Low vulnerability to delirium
- High precipitating factors
- Low precipitating factors
- Severe anxiety
- Other, demoralizing, high vulnerability factors
- Surgery, hospitalization
Knowing this, how can we prevent delirium in the postoperative patient?

Prevention Strategy

• Up to 40% of cases are preventable
• Identify risk factors in the preoperative period
• National Institute for Health and Care Excellence (NICE) defines at risk individuals as patients with any one of the following:
  • Age 65 and older
  • Any cognitive impairment, past or present
  • Dementia
  • Severe illness
  • Current hip fracture

Predisposing Factors

• Baseline cognitive impairment has the strongest correlation with acute postoperative delirium
• Many risk factors cannot be modified
• Reduction in the severity of risk factors can reduce the incidence of delirium
  • Correct visual and hearing impairment
  • Reduce immobility
Prevention Strategy – Precipitating Factors

• Extent of the operation is the main determinant of the precipitating insult
• Blood loss
• Length of operation
• Extent of dissection
• Anesthetic agent
• Type of anesthesia
• Medications
• Actively monitor, treat and avoid precipitating factors

Prevention Strategy – Precipitating Factors

• Each precipitating factor is a marker for a risk factor, has the potential to increase the severity of risk factors, or lead to the development of complications for which delirium may be a sign
• Use of catheters may lead to immobility or urinary tract infection, both of which may cause delirium
• Medications
• Sleep deprivation and altered sleep/wake cycle
• Neurologic events may precipitate delirium

Delirium Prevention Strategies

• Orientation
• Avoidance of restraints
• Family presence
• Eyeglasses
• Hearing aids
• Bladder and bowel regimen
• Maintain normal sleep/wake cycle
• Adequate pain management
• Early mobilization
• Adaptive equipment
• Adequate hydration
• Adequate oxygenation
• Medication review and avoidance of causative medications
Multicomponent Intervention Results

- Study intervention using standard protocols for 6 risk factors for delirium (cognitive impairment, sleep deprivation, immobility, visual impairment, hearing impairment and dehydration) versus routine care
  - Delirium 9.9% vs. 15%
  - Decreased total days with delirium and number of episodes
  - Concluded that primary prevention of delirium is the most effective treatment strategy

Inouye SK, NEJM, 1999

Reducing Delirium After Hip Fracture

- 126 patients 65 and older (mean 79 ± 8)
- Randomized to proactive geriatrics consultation before or within 24 hours of surgery vs. usual care
- Mean of 10 recommendations made with 77% compliance
- Delirium 32% with intervention, 50% in usual care
- Severe delirium in 12% with intervention vs. 29%
- Concluded that proactive geriatrics consultation reduced delirium by over one-third and severe delirium by one-half

Marcantonio ER, J Am Geriar Soc, 2001

Optimize Pain Control

- Increased levels of postoperative pain are associated with higher incidence of delirium
- Non-opioid medications may have benefit
  - Gabapentin
  - Acetaminophen
  - Celecoxib and other NSAIDs
Regional Anesthesia

- May be beneficial based on two small studies
- Mouzopoulos et al randomized hip fracture patients to regional anesthesia or placebo. Lower rates of delirium with fascia iliaca block (RR 0.13, 95% CI 0.03-0.53)
- Kinjo et al randomized total knee replacement patients to either femoral nerve block with PCA or PCA alone. Delirium in 25% of nerve block group compared with 61% in control group

Opioid Analgesics and Delirium

- Study of 541 hip fracture patients
- Patients who received < 10 mg morphine sulfate equivalents daily were more likely to develop delirium than patients given more analgesia (RR 5.4, 2.4-12.3)
- Patients given meperidine were more likely to develop delirium that those given other opioids (RR 2.4, 1.3-4.5)
- Severe pain significantly increased the risk of delirium (RR 9.0, 1.8-45.2)

Morrison RS, J Geront, 2003

Avoid Inappropriate Medication

- The most strongly associated medications:
  - Anticholinergic drugs
  - Diphenhydramine
  - Meperidine
  - Benzodiazepines
- The use of multiple medications (≥5) is associated with increased delirium risk
Early Mobilization

• Time to mobilization after hip fracture is an independent risk factor for delirium
• Multi-component intervention strategies that include early mobility have been shown to reduce the incidence of delirium

Anemia and Transfusion Strategy

• Results are conflicting with regard to transfusion threshold
• Two recent trials in orthopedic surgery have shown no reduction in delirium using a liberal transfusion trigger
• Transfusion has been a part of successful multi-component interventions

How is the diagnosis made?
Diagnosis – Clinical Features

- Inattention with the inability to focus
- Disorganized thinking
- Altered level of consciousness
- May be agitated or hyperactive
- Up to half may be hypoactive, presenting as somnolence, leading to poor recognition and under-diagnosis

Clinical Presentation

Confusion Assessment Method (CAM)

- Requires the presence of acute onset with a fluctuating course
  - Direct observation
  - History from family or providers
- Requires inattention
  - Counting backwards by 3’s or 7’s
  - Saying months in reverse order
- Either disorganized thinking or altered level of consciousness must also be present
  - Rambling speech or illogical flow of ideas
  - Lethargy/somnolence or hyperactivity/mania
Delirium may be present in up to 80% of ICU patients. The CAM-ICU is a useful adaptation for ICU patients. Can be completed in an average of 2 minutes. Sensitivity of 73% and specificity of 100% when compared to CAM.
How do I evaluate and treat a delirious patient?

Initial Evaluation of Delirious Patient

- Review history, functional assessment and medications
- Identify potential causes (IMCONFUSED)
- Other postoperative complications may present initially with delirium
  - Occult infection
  - Anastomotic leak
  - Hypoxia
  - Fluid and electrolyte imbalances
- Thorough evaluation to identify and treat these precipitating factors when present
**Etiology of Acute Confusion in Surgical Patients**

| I | Infection |
| M | Metabolic |
| C | Cognitive, sensory |
| O | Oxygenation |
| N | Nutrition, swallowing |
| F | Function, pharmacy, Foley catheter |
| U | Unfamiliar environment |
| S | Stress, pain |
| E | Electrolytes/fluids |
| D | Dysfunction lung, liver, kidney, brain |

**Treatment – Supportive Care**

- Treatment is directed at identifying the underlying cause, providing supportive care, and controlling symptoms.
- Supportive care uses many of the delirium prevention strategies.
- Ensure airway protection.
- Maintain oxygenation.
- Maintain fluid and electrolyte balance.
- Provide nutritional support.

**Treatment of Severe Agitation**

- Antipsychotics may be used for severe agitation, distress, or when behavior threatens harm to the patient or others.
- Use antipsychotics only after non-pharmacologic means have failed.
- The need for antipsychotics should be reassessed with daily exams.
Haloperidol for Severe Agitation

- Load with a 2 mg dose i.v. then repeat every 15-20 minutes, doubling dose, until agitation resolves
- Scheduled doses given every 4-6 hours for several days then tapered over several more
- QT prolongation may occur, leading to ventricular dysrhythmias such as torsades de pointes
- Extrapyramidal symptoms such as akathisia, dystonia and tardive dyskinesia may occur

Atypical Antipsychotics

- Risperidone, ziprasidone and quetiapine have been studied
- No recommendation have been made due to the lack of significant results and the heterogeneity of the studies
- Two small trials found quetiapine at doses of either 40 mg/day or 100 mg/day to be beneficial
  - Decreased time to resolution of delirium
  - Decreased time spent delirious
  - Less agitation
  - Increased rate of resolution of non-cognitive symptoms

Treatment of Hypoactive Delirium

- Antipsychotic medications and benzodiazepines should not be used to treat older adults with postoperative delirium who are not agitated or threatening harm to themselves or others
- No studies have shown a clinical benefit from treatment with these medications
- Significant potential harm from these medications exists in the setting of no clinical benefit
Benzodiazepines

• Should not be used as a first line treatment of severe agitation in a patient with postoperative delirium
• Only exception is treatment of benzodiazepine or alcohol withdrawal
  • Lowest dose
  • Shortest time
  • May promote delirium

Cholinesterase Inhibitors

• In older adults not taking cholinesterase inhibitors, these medications should not be prescribed to prevent or treat delirium
• Four trials have found no benefit in prophylactic use of cholinesterase inhibitors such as rivastigmine and donepezil
• Treatment groups in two studies showed trends toward increased adverse events, serious adverse events and mortality

Summary

• Postoperative delirium is a frequent and significant complication in the elderly
• Prevention is the best treatment
• Recognize delirium promptly
• Rapidly diagnose and treat the underlying factors
• Use medications only in cases of severe agitation
Questions?
Postoperative and Post-trauma Pulmonary Complications

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Hackensack, NJ

Conflict of Interest Disclosure

The Eastern Association for the Surgery of Trauma partners with the American College of Surgeons to provide continuing medical education credit. The American College of Surgeons is an accredited provider with the Accreditation Council for Continuing Medical Education.

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Conflict of Interest Disclosure

Author Disclosure

Brian Van Ness, MS, PA-C: NONE
Objectives

• Why postoperative pulmonary complications (PPC) matter?
• Categories of post-trauma and PPC
• Risk factors for PPC and post trauma pulmonary complications
• Prevention strategies
• Postoperative and post-trauma treatment strategies

Postoperative Pulmonary Complications

Pulmonary abnormality that produces identifiable disease or physiologic dysfunction that is clinically significant and adversely affects the normal clinical course, within 48-72 hours postoperatively

Scope of Pulmonary Complications

1° • Transient Hypoxemia
• Atelectasis

2° • Acute lung injury
• Pulmonary Infections

3° • ARDS
• Death
Why Does All of This Matter?

Quality and Outcomes

- PPCs occur twice as often as post op cardiac events (9.6% vs. 5.7%)
- Ventilator associated pneumonia (VAP)
  - 5.2 cases/1000 ventilator days in Surgical ICUs
  - 10.2 cases/1000 ventilator days in Trauma ICUs
- Healthcare associated pneumonia (HCAP)
  - Prolongs hospital stays for an average of 7-9 days


Quality and Outcomes

- Post-op pneumonia = #2 reason for unplanned readmission postoperatively
- Any PPC increases lengthy of stay (LOS) by 8 days on average
- 2008 review
  - More than 1 million patients experienced a PPC
  - 46,200 deaths
  - 2.9 million additional days on the floor
  - 1.9 million additional days in the ICU

Cost

- VAP
  - Estimated cost of treatment per patient $11,000 to $57,000
- Medicare study, 2004 cost of all unplanned rehospitalizations → $17.4 BILLION
  - 22% of these = postoperative readmissions
- Annually
  - PPCs = $3.4 billion in health care costs

Defining and Categorizing the Problem

Postoperative Pulmonary Complications

- Incidence 5-80%
- 5-10% of all post-surgical patients
- 25% of deaths within 7 days
Postoperative Pulmonary Complications

- Most common post surgical complication
- Major surgical procedures
- Critically ill
- Increase LOS
- Decrease short and long term survival

Categories

- Atelectasis
- Aspiration
- Pulmonary vascular congestion
- Pneumonia
- Acute respiratory failure
- Other

Atelectasis

[Images of x-rays showing atelectasis]
Atelectasis

- Majority of all PPCs
- Abdominal and thoracoabdominal cases
- Primary mechanism in acute lung injury (ALI)

Physiologic Mechanisms
- Obstruction of the tracheobronchial tree
  - Secretions, inability to cough
- Hypoventilation
  - Anesthetics, narcotics, under-treated pain

Aspiration

- Absence of normal protective mechanisms
- Consequence of surgical procedure
- Consequence of pre-existing condition

Prevention
- NPO 6-8 hours prior to OR
- Gastric decompression prior to anesthetic induction
Pulmonary Vascular Congestion

- Non-cardiogenic
  - Volume overload (most common)
    - Excessive crystalloid/colloid infusion
- Cardiogenic
  - Decreased contractility due to:
    - Cardiac disease
    - Anesthetic/narcotic/hypnotic agent effects
    - Acute ischemic cardiac events

Other PPC

- Exacerbation of underlying lung disease
  - COPD, asthma
- Pulmonary complications related to inadequately treated pain
- Tracheal injury secondary to intubation
What Puts Patients at Risk for Pulmonary Complications?

Medical History Risk Factors
- Major Risks
  - COPD
  - CHF
  - Total functional dependence
  - ASA Physical score > 2
- Minor Risks
  - NIDDM/IDDM
  - Protein calorie malnutrition
  - Liver failure
  - CKD
  - Altered mental status

Social History Risk Factors
- Weight loss > 10% in previous 6 months
- Smoking pre-op goals
  - 6-8 weeks of abstinence = most beneficial
  - Peak flow > 80%
  - Absence of wheezing
Procedure-Related Risk Factors

- Highest risk procedures
  - Abdominal aortic aneurysm repair
  - Thoracic surgery
  - Upper abdominal surgery
  - Operative procedures > 3hr
  - Vascular surgery
  - Emergency surgery

Surgical Site/Technique Risk Factors

- Distance of the incision from the diaphragm
  - Aortic/esophageal = 20-25%
  - Upper abdominal = 20-25%
  - Lower abdominal = 5-10%
  - Laparoscopic vs. open procedures

Other Risk Factors for PPC

- Perioperative transfusion of > 4 units PRBC
  - TRALI
- Low albumin (< 3.5 g/dL)
  - Preoperative nutrition does not afford a protective benefit against PPCs
  - Questionable benefit in small sub-group
  - Consider pre op nutrition supplements if time allows
Trauma Specific Risk Factors for Pneumonia and Respiratory Failure

Pneumonia in Trauma
National Trauma Data Bank 2013

#1 post-trauma hospital complication?
Pneumonia

Pneumonia Risk Factors

- Intubation in the field + any of these risk factors
  - Intubation alone does not increase risk
- One or > rib fractures
- High ISS (>15)
- Documented aspiration
- Presence of parenchymal lung injury or hemothorax
- Administration of blood products
- Severe TBI (GCS <8 and/or hemiplegia/hemiparesis) or severe neck trauma
Acute Respiratory Failure in Trauma
National Trauma Data Bank 2013

#3 in-hospital complication?

ALI/ARDS

Respiratory Failure Risk Factors

• Risk Factors
  • Age >65
  • Male gender
  • ISS >20
  • Any rib fracture or parenchymal injury on CXR
  • Rib fracture in >1 anatomic location on CT scan

Acute Postoperative and Post-Trauma Respiratory Failure
Acute Postoperative Respiratory Failure

- Definitions
  - Failure to extubate within 48 hours of surgery
- More Common
  - Multi-system organ failure
  - Multi-system trauma
- In-hospital mortality rate = 40% vs. 6% in those without acute postoperative respiratory failure

Acute Postoperative Respiratory Failure

- Etiologies
  - Sepsis
  - Massive transfusion
  - Pulmonary emboli
  - Pancreatitis
  - Aspiration
  - Anesthetic effects
  - Intravascular volume overload

Causes of Respiratory Failure

- Failure to Ventilate
  - Neurological
  - Muscular
- Failure to Maintain Airway
  - Obstructed airway
- Failure to Oxygenate
  - Diffusion abnormality
  - V/Q mismatch
  - Dead space ventilation

Hypoxemic Respiratory Failure

- PaO2 < 60 mmHg on room air
  - 1° Diffusion defects/VQ mismatch
    - Alveolar dead space (PE)
    - Physiologic shunt (ARDS, PNA, plug)
  - 2° Metabolic/cellular abnormalities
    - Adequate delivery and alveolar VQ, inability to extract O₂ at cellular level (sepsis)

Hypercarbic Respiratory Failure

- PaCO₂ > 50 mmHg
  - CNS
  - Thoracic trauma
  - Obesity
  - Endotracheal tube obstruction/displacement
  - Alveolar level → VQ mismatch
Acute Respiratory Failure
Due to Loss of Airway

• Bronchospasm
• Airway edema
• Extrinsic airway compression
• Neurologic impairment
• Absence of gag/cough reflexes

When in doubt, INTUBATE/REINTUBATE

Postoperative and Post-trauma Pneumonia

Non-infectious Causes of Fever and Infiltrates Masquerading as Pneumonia

• Aspiration pneumonitis
• Atelectasis
• Pulmonary embolus
• Pulmonary hemorrhage
• Lung contusion
• Infiltrative mass
• Medication reactions
Healthcare Associated Pneumonia (HCAP)

- Positive sputum bacterial culture > 48hr after admission
- Second most common nosocomial infection
- Most common cause of death in ICU setting
- Accounts for 25% of all ICU infections
- Leading cause of mortality attributed to nosocomial infections at 33-50%
- 5-10 cases per 1,000 hospital admissions


Ventilator Associated Pneumonia (VAP)

- Positive sputum culture
  - Mechanically ventilated
  - > 48hr after admission or tracheal intubation
- Most common hospital acquired ICU infection
- 10-20% mechanically ventilated patients
- Risk of pneumonia, mechanically ventilated patient
  - 3% per day first 5 days
  - 2% per day on days 5-10
  - 1% per day thereafter


VAP Diagnostic Criteria

- CXR: new infiltrate/cavitation/consolidation
- At least one:
  - Temperature (>38°C or >100.4°F)
  - WBC (<4,000) or >12,000)
  - Altered mental status (>70 y/o)
- At least two:
  - New or worsening sputum production
  - New or worsening cough/dyspnea/tachypnea or worsening P:F ratio

Postoperative Pneumonia

- HCAP or VAP in a postoperative patient
- Bacterial, onset within 5 days of surgery
- Significant risk factors
  - Duration in the healthcare environment
  - Recent exposure to antibiotics
  - Rule out other likely causes of fever
    - Wound infection
    - UTI
    - Atelectasis

Postoperative Pneumonia Pathogens

- Initial/early onset
  - Staph aureus (post op neurologic surgery, coma/TBI)
  - Strep pneumo & H. Influenzae (traumatic injury)

- Late Onset
  - Aerobic gram negative bacilli
    - Pseudomonas, Klebsiella sp, Acinetobacter sp, E. Coli, Enterobacter sp, Serratia sp
  - MRSA
    - Predominant gram + pathogen in the ICU setting
    - Diabetes, traumatic brain injury, critical care setting

Postoperative Pneumonia Pathogens

- Pseudomonas
  - Mechanical ventilation >8d, antibiotic therapy for >48hrs in the 10 days preceding the PNA

- Acinetobacter species
  - Mechanical ventilation
  - But NO specific surgery or traumatic injury related pattern

- Anaerobic
  - Rare
  - Except aspiration pneumonia in non-intubated patients (BiPAP)
Strategies for the Prevention of Postoperative Pulmonary Complications

Gastric Decompression
- Targeted/selective usage of nasogastric tube decompression vs. routine placement
- Direct path for oropharyngeal bacteria → lungs
- Nasal vs. oral tubes

Anesthetic Options
- No strong evidence to recommend one anesthetic technique over another
- Intermediate duration NMBs (Atracurium) vs. long duration NMBs (Pancuronium)
- Neuraxial blockade (spinal or epidural)
**Intra-op Lung Protective Ventilation?**

- **PROVHILO STUDY (n = 900), 2011-2013, RCT**
  - Two groups
    - Lung protective: $V_t < 8mL/kg$ predicted body wt, PEEP $+12$, recruitment maneuvers
    - Conventional: $V_t < 8mL/kg$ predicted body wt, PEEP 0-2, no recruitment maneuvers
  - Results
    - No significant difference in PPC between the two groups
    - Higher PEEP group = intra-op hypotension & vasopressors
  - Recommendations
    - Low $V_t$, low/conventional PEEP levels, no recruitment maneuvers

The PROVE Network Investigators for the Clinical Trial Network of the European Society of Anaesthesiology. The Lancet 2014; 384: 495-505

**Lung Expansion and Lung Capacity Restoration Techniques**

- Prevention
  - Control pre-existing pulmonary disease pre-op
  - Cessation of smoking 8 weeks preoperatively
  - Incentive spirometry
  - Cough/deep breath exercise
  - Chest PT
  - Early mobilization
  - No single modality better than another
  - Combination therapies do NOT improve risk reduction
  - **ANY type of lung expansive technique is better than NONE AT ALL**

Lawrence VA, Cornell JE, Smetana GW. Ann Inter Med 2006;144(8):596-608

**Postoperative Analgesia**

- Most important postoperative intervention
- Epidural
  - Vs. PCA
    - Equal in terms of PPC reduction
  - Vs. on demand opioids
    - Epidural superior in terms of PPC reduction
  - Vs. systemic parenteral opioids
    - Reduction in atelectasis, not pneumonia

Case Study

70M, POD #3 s/p extensive lysis of adhesions and small bowel resection secondary to prolonged SBO with minimal PO intake x 7 days. Admitted to SICU, mechanically ventilated.

- HOB is 15 degrees
- Versed infusion at 8 mg/hr
- NPO
- Blood glucose ranges 190-240
- 2 units of PRBC for Hgb 8.6 overnight
- Antibiotics: Linezolid and Piperacillin/Tazobactam, with no positive cultures, fever or leukocytosis

Which of these treatment modalities put this patient at risk of healthcare-ventilator associated pneumonia?

---

2005 ATS/IDSA Non-pharmacologic Strategies to Prevent Nosocomial Pneumonia

<table>
<thead>
<tr>
<th>Strategy</th>
<th>Evidence Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hand washing/decontamination</td>
<td>Level I</td>
</tr>
<tr>
<td>Non-invasive positive pressure</td>
<td>Level I</td>
</tr>
<tr>
<td>ventilation/avoid intubation</td>
<td>Level I</td>
</tr>
<tr>
<td>Avoid reintubation</td>
<td>Level I</td>
</tr>
<tr>
<td>Utilize subglottic suctioning</td>
<td>Level I</td>
</tr>
<tr>
<td>Semi-erect positioning</td>
<td>Level I</td>
</tr>
<tr>
<td>Enteral/small bowel nutrition</td>
<td>Level I</td>
</tr>
<tr>
<td>Use orogastric/orotracheal tubes</td>
<td>Level II</td>
</tr>
</tbody>
</table>

Subglottic Suctioning

- ETT cuff pressure @ 20cm H2O
  - Dual lumen tubes
    - Do reduce risk of VAP/HAP
    - Do not improve mortality, ICU LOS, duration of mechanical ventilation
Prevention Strategies

- Short duration mechanical ventilation
- Develop standardized weaning protocols
- Enteral nutrition better than parenteral
  - Fewer episodes of pneumonia
  - No difference in mortality gastric vs. post-pyloric feeds


58

Adapted from Kollef, M. Prevention of postoperative pneumonia. Hosp Physician 2007: 54

2005 ATS/IDSA Pharmacologic Strategies to Prevent Nosocomial Pneumonia

<table>
<thead>
<tr>
<th>Strategy</th>
<th>Evidence grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avoid antibiotic prophylaxis</td>
<td>Grade I</td>
</tr>
<tr>
<td>Avoid unnecessary RBC transfusion</td>
<td>Grade I</td>
</tr>
<tr>
<td>Blood glucose control with insulin</td>
<td>Grade I</td>
</tr>
<tr>
<td>Oral decontamination</td>
<td>Grade I</td>
</tr>
<tr>
<td>Short duration antibiotic therapy</td>
<td>Grade I</td>
</tr>
<tr>
<td>Avoid unnecessary GI prophylaxis</td>
<td>Grade I</td>
</tr>
</tbody>
</table>

Grade I


Prevention Strategies

- Oropharyngeal decontamination
  - Mixed study results
  - Definitely better than placebo at reduction of VAP/HAP
  - Low cost, minimal/no side effects and lack of resistance

Case Study

Recall, current treatments:
- HOB is 15 degrees
- Versed infusion at 8 mg/hr
- NPO
- Blood glucose ranges 190-240
- 2 units of PRBC for Hgb 8.6 overnight
- Antibiotics: Linezolid and Piperacillin/Tazobactam, with no positive cultures, fever or leukocytosis

Which put patient at risk for VAP/HAP?
THEY ALL DO!

Treatment Strategies for Pulmonary Complications

Case

32M, post trauma day #2, s/p MVC: L flail chest, L pulmonary contusion, L pneumothorax s/p chest tube, mechanically ventilated with persistent high plateau pressures and refractory hypoxemia.
Vent: PRVC 20/400/+18/100%
ABG: 7.36/40/52/24/-4
Hgb 7.6, Creatinine 3.2

- What adjunctive therapies are available for this patient to improve oxygenation?
- Is nitric oxide an option? Or high frequency oscillatory ventilation? Steroids? PRBC transfusion?
Mechanically Ventilated Patients

ARDSnet Protocol

- Maximize alveolar recruitment
- Prevent cycles of recruitment/derecruitment
- Minimize FiO2, "optimal" PEEP
- Minimize alveolar overdistention and lung injury
  - Plateau pressure = most predictive of ALI
  - Measures static compliance in the ABSENCE of gas flow = tidal volume/compliance
  - Goal < 30 cmH₂O
  - Adjust TV to achieve
- Adjust tidal volume and respiratory rate to pH 7.30-7.45

Plateau Pressure

- Peak pressure
- Plateau pressure
- Resilient pressure
- Elastic pressure

Neuromuscular Blockade (NMB)

- Multicenter, double blind study, n = 340
  - Cisatracurium x 48 hr. or placebo infusion in severe ARDS of < 48 hr. duration
  - Mixed medical/surgical
  - Early administration of NMB agents improved 90 day survival
  - Increased time off mechanical ventilator
  - No residual muscle weakness

High Frequency Oscillatory Ventilation

- OSCAR trial
  - 795 patients, multicenter randomized trial
  - HFOV vs. conventional ventilation
  - No significant difference in 30 day mortality

- OSCILLATE trial
  - Intended 1,200 patients, stopped after 548 patients
  - Increased use of dose benzodiazepines, neuromuscular blockade, vasopressors
  - Early initiation of HFOV in moderate to severe ARDS does not reduce and may increase hospital mortality (47% vs. 35%)

Corticosteroids

- 2014 meta-analysis
  - Effects of corticosteroids inconsistent due to:
    - Differing outcome measures
    - Heterogeneity of population and disease state studies
  - Conclusions:
    - Do not improve long term (>60 day) mortality
    - Might improve short term mortality
    - Might have some benefit in a subgroup of patients with persistent lung inflammation and ARDS with initiation <14 days after inciting event
    - Definitely increase mortality when used late in ARDS, >14 days
    - Side effects negate short term gains
      - Hyperglycemia, infection, immunosuppression
    - Can not be routinely supported for use in ARDS
**Fluid Balance**

**FACTT trial (n = 1000)**
- Restrictive vs. liberal IV fluid in ALI
  - CVP or PCWP and CI parameters
  - Restrictive strategy:
    - **Did not improve** 60 day mortality (1st endpoint)
    - Improved lung function
    - Shortened mechanical ventilation times/ICU days
    - No increase in non-pulmonary organ failure


**Nitric Oxide**

2014 meta-analysis
- **Transiently** improves oxygenation
- Expensive
- Dose & titration questions
- Potentially harmful
  - Acute kidney injury
  - Has not been shown to:
    - Increase ventilator free days
    - Improve mortality

Adhikari N, Dellinger R, Lundin S. Crit Care Med 2014;42(2):404-412

**Prone Ventilation**

- Early, severe ARDS, prospective, randomized study
  - n = 66
  - 16 hours prone vs. supine mechanical ventilation
  - No difference in complications except cardiac arrest higher in supine group
  - Prone group:
    - 16% vs. 33% mortality at 28 days
    - 24% vs. 41% mortality at 90 days

Guerin, C, et al. NEJM 2013; 368: 2159-2168
Acute Anemia

• Conservative PRBC approach
  • Transfusion threshold Hgb < 7 gm/dL
• Exceptions
  • Active cardiac ischemia
  • Active hemorrhage


Summary

Minimize ventilator induced lung injury by:

• Avoid volutrauma
  • Alveolar distention
• Avoid atelectrauma
  • Repetitive opening/closing
• Avoid biotrauma
  • Lung inflammation
• Avoid oxygen toxicity

Case Study

Recall:
32M, post trauma day #2; s/p MVC: L flail chest; L pulmonary contusion; L pneumothorax s/p chest tube; persistent high plateau pressures and refractory hypoxemia.
Vent: PRVC 20/400/+18/100%
ABG: 7.36/40/52/24/-4
Hgb 7.6, Creatinine 3.2
-NO not indicated
-HFOV not indicated
-Transfusion not indicated
-Too early for steroids
-Consider NMB
-Consider prone ventilation
-Control plateau pressure
Utilize ARDSnet protocol
Antibiotic Therapy Principles

- Initially broad spectrum, adequately dosed regimen
- Geographic variability of bacteriology
- Short duration antibiotic therapy
  - Reduces risk of infection with resistant bacteria
  - 7 days uncomplicated non-bacteremic infections with appropriate clinical response
    - Except Pseudomonas
  - De-escalate or discontinue all empiric antibiotics after 48-72 hours
    - Cultures negative or signs of infection have resolved

Case Study

42M post trauma day #10, severe TBI. Not mechanically ventilated, in the surgical step down unit. Day #3 of Piperacillin/Tazobactam and Vancomycin due to fevers, leukocytosis and cough. Deep bronchial culture, UA and blood cultures all negative. Currently afebrile, normal WBC count, negative CXR

SHOULD HIS ANTIBIOTIC REGIMEN BE STOPPED OR DE-ESCALATED?

Other Treatment Strategies for Pulmonary Complications
Avoid Unnecessary GI Prophylaxis

- 0.5-5% incidence stress-related mucosal bleeding in critically ill patients
- Independent Risk Factors:
  - Mechanical ventilation >48 hours
  - Coagulopathy (Platelet count <50,000, INR > 1.5 or PTT > 2x control)
- Other Risk Factors:
  - Shock/hypoperfusion with associated organ dysfunction (AKI)
  - Burns >35% TBSA
  - Severe TBI (GCS <8), severe spinal cord injury
  - Concomitant use of NSAIDs
  - Glucocorticoid therapy (>250 mg Hydrocortisone or equivalent)
- Negative Risk Factor:
  - Enteral nutrition


Avoid Unnecessary GI Prophylaxis

- H2 receptor antagonists vs. proton pump inhibitors
  - Equal efficacy
  - PPI; GERD or recent GI bleeding
  - Why not PPI's for all
    - Risk of nosocomial pneumonia (9.3% vs. 1.5%)
    - Association in multiple trials with C. Difficile infection


Hyperglycemia

- Trauma
  - Increase mortality rate, LOS, ventilator days
  - Worse neurologic outcomes in TBI
- Surgical
  - Higher mortality & nosocomial infection rates
  - Intensive insulin therapy (80-120 mg/dL)
    - Increased rate of hypoglycemia, adverse events
  - Conventional therapy (140-180 mg/dL)
    - Less hypoglycemic events
    - No increase in mortality and improved outcomes

Pain Control/Sedation

- 2013 SCCM Pain, Analgesia, Delirium guidelines
- **Maximize** narcotic usage in trauma/surgical patients
- **Minimize** benzodiazepine sedation
  - Prolongs mechanical ventilator weaning
  - Increases risk of delirium
- **Utilize** non-benzodiazepine sedation, if indicated
  - Propofol and Dexmedetomidine
- **Utilize** non-narcotic alternatives
  - Parenteral/oral NSAIDS, parenteral/oral Acetaminophen
- Selective use of neuraxial blockade may facilitate faster ventilator weaning and improve pain control
  - AAA repair, rib fractures

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“In the mindset of the data-driven, cost conscious, nonclinical performance examiner, any postoperative complication may be viewed as iatrogenic in nature and therefore a non-reimbursable service”


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Summary

- Early recognition of modifiable risk factors
- Pre-op strategy to combat post-op complications
- Employ any lung expansion therapy
- Utilize post-op risk reduction strategies that work
- Know local microbiologic flora and tailor antibiotics
- Recognize post trauma risk factors
- Employ proven ventilator strategies for lung protection and prevention of PNA