Clinical Pathways & Post-Operative Management of Appendicitis

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Case Presentation

- This case presentation is based on a true story.
• 29 y F with 2 days RLQ pain, nausea, emesis

• PMH: none
• Meds: none

• Vitals: normal
• Exam: +RLQ tenderness, + Rovsing sign

• 16.8> 13.1/43.7 <262  89.5% neut

• CT A/P: acute appendicitis
• **To OR (attending #1):**
  - Open appendectomy
  - Purulent, gangrenous appendicitis
  - Fascia closed, skin left open
  - Case completed at 3am

• **Post-Op plan:**
  - NPO, IV fluids
  - IV antibiotics x72 hours
• POD 0 AM Rounds (6am):
  – Looked great
  – Diet started

• Attending #2 Rounds (9am):
  – Tolerating diet, IV fluids stopped
  – CBC ordered for next AM
• POD 1 AM Rounds (6am):
  – Wound clean, skin approximated

• Attending #3 Rounds (9am):
  – WBC 13
  – Converted to PO antibiotics

• Discharged later that day (6pm):
  – 3 days more of PO antibiotics
  – (4 days total)
Clinical Pathway – Definition

• Tool for management of a specific problem
  – Based on best evidence
  – Tasks are defined, optimized, and sequenced
  – Multi-disciplinary

• AKA algorithm, roadmap

• NOT the same as guidelines
Guidelines vs Pathways

• Guideline example:
  - After colectomy for colon cancer, medical oncology follow up is recommended to evaluate for adjuvant therapy

• Pathway example:
  - Medical oncology consult is part of post-colectomy order set
  - Pre-written discharge instructions have space for date & time of appointment
Advantages

- All steps are outlined
  - Reduce the likelihood of “misses”

- Less variability in outcomes based on individual personnel

- Coordinate disparate members of care team
Disadvantages

• May not reflect “best practice”
  – Frequent updates needed to reflect new research

• Some cases require individualized care

• Requires buy-in from all members of team
Example – Airline Industry

Examples in Medicine

- Central line placement
- Septic shock
- Ventilator weaning
Central Line Placement

• Central line bundle
  – **Standardized supplies and steps**
    • Wash hands, sterile technique
    • Central line cart – has all supplies needed
    • Checklist to ensure infection control measures taken
    • Daily discussion of need for lines

• Keystone ICU Project
  – 108 ICUs in Michigan implemented central line bundles and tracked outcomes
    • Primary: Catheter related bloodstream infections

### Table 3. Rates of Catheter-Related Bloodstream Infection from Baseline (before Implementation of the Study Intervention) to 18 Months of Follow-up. 

<table>
<thead>
<tr>
<th>Study Period</th>
<th>No. of ICUs</th>
<th>Overall (median (interquartile range))</th>
<th>Teaching Hospital (median (interquartile range))</th>
<th>Nonteaching Hospital (median (interquartile range))</th>
<th>&lt;200 Beds (median (interquartile range))</th>
<th>≥200 Beds (median (interquartile range))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>55</td>
<td>2.7 (0.6–4.8)</td>
<td>2.7 (1.3–4.7)</td>
<td>2.6 (0–4.9)</td>
<td>2.1 (0–3)</td>
<td>2.7 (1.3–4.8)</td>
</tr>
<tr>
<td>During</td>
<td>96</td>
<td>1.6 (0–4.4)†</td>
<td>1.7 (0–4.5)</td>
<td>0 (0–3.5)</td>
<td>0 (0–5.8)</td>
<td>1.7 (0–4.3)†</td>
</tr>
<tr>
<td>After</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0–3 mo</td>
<td>96</td>
<td>0 (0–3)‡</td>
<td>1.3 (0–3.1)†</td>
<td>0 (0–1.6)†</td>
<td>0 (0–2.7)</td>
<td>1.1 (0–3.1)‡</td>
</tr>
<tr>
<td>4–6 mo</td>
<td>96</td>
<td>0 (0–2.7)‡</td>
<td>1.1 (0–3.6)†</td>
<td>0 (0–0)‡</td>
<td>0 (0–0)†</td>
<td>0 (0–3.2)‡</td>
</tr>
<tr>
<td>7–9 mo</td>
<td>95</td>
<td>0 (0–2.1)‡</td>
<td>0.8 (0–2.4)‡</td>
<td>0 (0–0)‡</td>
<td>0 (0–0)†</td>
<td>0 (0–2.2)‡</td>
</tr>
<tr>
<td>10–12 mo</td>
<td>90</td>
<td>0 (0–1.9)‡</td>
<td>0 (0–2.3)‡</td>
<td>0 (0–1.5)‡</td>
<td>0 (0–0)†</td>
<td>0.2 (0–2.3)‡</td>
</tr>
<tr>
<td>13–15 mo</td>
<td>85</td>
<td>0 (0–1.5)‡</td>
<td>0 (0–2.2)‡</td>
<td>0 (0–0)‡</td>
<td>0 (0–0)†</td>
<td>0 (0–2.0)‡</td>
</tr>
<tr>
<td>16–18 mo</td>
<td>70</td>
<td>0 (0–2.4)‡</td>
<td>0 (0–2.7)‡</td>
<td>0 (0–1.2)†</td>
<td>0 (0–0)†</td>
<td>0 (0–2.6)‡</td>
</tr>
</tbody>
</table>

* Because the ICUs implemented the study intervention at different times, the total number of ICUs contributing data for each period varies. Of the 103 participating ICUs, 48 did not contribute baseline data. P values were calculated by the two-sample Wilcoxon rank-sum test. 
† P ≤ 0.05 for the comparison with the baseline (preimplementation) period. 
‡ P ≤ 0.002 for the comparison with the baseline (preimplementation) period.

• Overall decrease 66% at 18 months

Septic Shock

- Early goal directed therapy

Septic Shock

• Eligible: patients meeting SIRS criteria in ED
  – Randomized to standard therapy or early goal directed therapy
    • Standard therapy still followed a protocol!!
      – Placing lines, sending cultures, early critical care consultation
      – Did not have specific target parameters

• 263 patients enrolled
  – Intention to treat analysis

### TABLE 3. Kaplan–Meier Estimates of Mortality and Causes of In-Hospital Death.*

<table>
<thead>
<tr>
<th>VARIABLE</th>
<th>STANDARD THERAPY (N=133)</th>
<th>GOAL-DIRECTED THERAPY (N=130)</th>
<th>RELATIVE RISK (95% CI)</th>
<th>P VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>In-hospital mortality†</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All patients</td>
<td>59 (46.5)</td>
<td>38 (30.5)</td>
<td>0.58 (0.38–0.87)</td>
<td>0.009</td>
</tr>
<tr>
<td>Patients with severe sepsis</td>
<td>19 (50.0)</td>
<td>9 (14.9)</td>
<td>0.46 (0.21–1.08)</td>
<td>0.06</td>
</tr>
<tr>
<td>Patients with septic shock</td>
<td>40 (56.8)</td>
<td>29 (42.3)</td>
<td>0.60 (0.36–0.98)</td>
<td>0.04</td>
</tr>
<tr>
<td>Patients with sepsis syndrome</td>
<td>44 (45.4)</td>
<td>35 (35.1)</td>
<td>0.66 (0.42–1.04)</td>
<td>0.07</td>
</tr>
<tr>
<td>28-Day mortality†</td>
<td>61 (49.2)</td>
<td>40 (33.3)</td>
<td>0.58 (0.39–0.87)</td>
<td>0.01</td>
</tr>
<tr>
<td>60-Day mortality†</td>
<td>70 (56.9)</td>
<td>50 (44.3)</td>
<td>0.67 (0.46–0.96)</td>
<td>0.03</td>
</tr>
<tr>
<td>Causes of in-hospital death‡</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sudden cardiovascular collapse</td>
<td>25/119 (21.0)</td>
<td>12/117 (10.3)</td>
<td>—</td>
<td>0.02</td>
</tr>
<tr>
<td>Multiorgan failure</td>
<td>26/119 (21.8)</td>
<td>19/117 (16.2)</td>
<td>—</td>
<td>0.27</td>
</tr>
</tbody>
</table>

*CI denotes confidence interval. Dashes indicate that the relative risk is not applicable.
†Percentages were calculated by the Kaplan–Meier product-limit method.
‡The denominators indicate the numbers of patients in each group who completed the initial six-hour study period.
Ventilator Weaning

• Protocol-directed weaning:
  – Steps initiated by critical care nurses and respiratory therapists when triggered by clinical parameters

• 357 patients randomized to protocol-directed weaning or physician-directed weaning
  – 4 ICUs at 2 hospitals

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Protocol-Directed Weaning (n = 179)</th>
<th>Physician-Directed Weaning (n = 178)</th>
<th>Observed Difference Between Groups (95% CI)&lt;sup&gt;a&lt;/sup&gt;</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duration of MV before start of weaning (hr)</td>
<td>39.6 ± 81.7&lt;sup&gt;b&lt;/sup&gt;</td>
<td>58.3 ± 101.1</td>
<td>-18.7 (-40.2 to 2.8)</td>
<td>0.016</td>
</tr>
<tr>
<td></td>
<td>[17]&lt;sup&gt;c&lt;/sup&gt;</td>
<td>[22]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Duration of MV (hr)</td>
<td>69.4 ± 123.7</td>
<td>102.0 ± 169.1</td>
<td>-32.6 (-63.4 to -1.8)</td>
<td>0.029</td>
</tr>
<tr>
<td></td>
<td>[28]</td>
<td>[35]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Requiring MV for &gt;7 days, n (%)</td>
<td>21 (11.7)</td>
<td>31 (17.4)</td>
<td>-5.7 (-13.0 to 1.6)</td>
<td>0.128</td>
</tr>
<tr>
<td>Required reintubation, n (%)</td>
<td>23 (12.8)</td>
<td>18 (10.1)</td>
<td>2.7 (-4.0 to 9.4)</td>
<td>0.417</td>
</tr>
<tr>
<td>Hospital mortality, n (%)</td>
<td>40 (22.3)</td>
<td>42 (23.6)</td>
<td>-1.3 (-10.1 to 7.5)</td>
<td>0.779</td>
</tr>
<tr>
<td>Hospital length of stay (days)</td>
<td>12.7 ± 9.4</td>
<td>14.2 ± 11.7</td>
<td>-1.5 (-3.7 to 0.7)</td>
<td>0.517</td>
</tr>
</tbody>
</table>

CI, confidence interval; MV, mechanical ventilation.
<sup>a</sup>Values are given as observed differences in population means or observed differences in percentages; <sup>b</sup>mean ± SD; <sup>c</sup>numbers in brackets represent median values.
Cochrane Review

• 27 randomized studies
  – Clinical pathway vs usual care

• Findings:
  – Absolute risk reduction of 5.6% in complications
    • 17 patients needed to treat to prevent 1 complication
  – Documentation improved
  – LOS decreased
  – Resource utilization decreased

Post-Operative Management of Appendicitis
“Acute appendicitis: is there a difference between children and adults?”

Appendicitis Severity Continuum

- Simple
- Gangrenous
- Perforated

- Simple
- Complicated
Surgeon vs Pathologist

• Comparison of surgeon diagnosis of appendicitis to pathologist
  – 69 patients

• Complicated appendicitis
  – Surgeon: 36.2%
  – Pathologist: 43%
  – p=0.03
  – $\kappa=0.25$

Clinical Pathways in Appendicitis

• 1983: first report of improvements using protocol for appendicitis (in children)

• Numerous studies demonstrate improvements based on:
  – Shortening course of IV antibiotics
  – Shortening course of PO antibiotics
  – Shortening LOS

• Compare a new protocol to old protocol
  – What about compared to “usual care”??
Clinical Pathway vs Usual Care

• 1 surgeon used pathway (n=197)
• 2 surgeons used “tailored” approach (n=228)

• Pathway:
  – **Simple**: no antibiotics, no labs, advance diet
    • Discharge once tolerating PO
  – **Complicated**: IV antibiotics, CBC when afebrile x24 hrs & ROBF
    • If WBC normal, discharge with no antibiotics
    • If elevated, discharge with antibiotics (usually PO)

Clinical Pathway vs Usual Care

• Simple appendicitis:
  – Reduced post-operative IV antibiotics (16% vs 80%)
  – Reduced hospital length of stay by 24%
  – Reduced hospital charges by 14%

• Complicated appendicitis:
  – Reduced number of patients having drain placed (3.6% vs 27%)
  – Reduced number of patients discharged on antibiotics (13% vs 39%)

Effect of Pathway on Resource Utilization

- 410 children with perforated appendicitis

- Retrospective review, comparison of pre- and post-protocol outcomes

- Protocol determined:
  - Antibiotic type, timing
  - Lab collections
  - Diet advancement

Table 1  Resource utilization before and after the implementation of the protocol.

<table>
<thead>
<tr>
<th></th>
<th>Before (n = 151)</th>
<th>After (n = 259)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>NGT leaving operating room (%)</td>
<td>72.2</td>
<td>3.9</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>NGT placed on floor (%)</td>
<td>4.0</td>
<td>2.7</td>
<td>0.7779</td>
</tr>
<tr>
<td>Use of peripherally inserted central catheter (%)</td>
<td>65.6</td>
<td>17.8</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Use of total parenteral nutrition (%)</td>
<td>43.7</td>
<td>5.0</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Time to start regular diet (days)</td>
<td>4.0 ± 2.3</td>
<td>2.6 ± 1.4</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Number of IV antibiotics used</td>
<td>3.1 ± 0.7</td>
<td>2.0 ± 0.2</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Maximum number of IV antibiotic doses per day</td>
<td>9.5 ± 2.1</td>
<td>2.1 ± 0.5</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Patients discharged on oral antibiotics (%)</td>
<td>70.9</td>
<td>47.5</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Days of home antibiotics</td>
<td>2.9 ± 5.3</td>
<td>3.6 ± 5.0</td>
<td>0.2</td>
</tr>
<tr>
<td>Number of lab tests</td>
<td>6.7 ± 3.3</td>
<td>2.3 ± 1.8</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Number of CT scans</td>
<td>1.3 ± 1.2</td>
<td>1.3 ± 0.8</td>
<td>0.86</td>
</tr>
<tr>
<td>Duration of hospitalization (days)</td>
<td>8.0 ± 3.5</td>
<td>6.8 ± 3.5</td>
<td>0.0007</td>
</tr>
</tbody>
</table>

Effect of Pathway on Resources & Outcomes

- Complicated appendicitis in children

- Pre-clinical pathway: 191 patients
- Post-clinical pathway: 122 patients

Pathway:
- IV zosyn after surgery
- Transition to PO cipro/flagyl when tolerating diet
- No CBC
- 7 days total course
- CT scan at 7 days if failure to improve

Resource utilization decreased:

- CBC (44% vs 4.1%)
- PICC placement (30.4% vs 2.5%)
- IR procedure (12% vs 2.5%)
- TPN (11.5% vs 1.6%)
- CT scan (29.3% vs 13.1%)

Clinical outcomes improved:

- Organ-space SSI (24.1% vs 9.8%)
- Return to OR (9.4% vs 3.3%)
- 30d readmission (16.2% vs 11.5%)
“No matter what technique is used, if everyone in the hospital uses the same protocol and pays attention to following the plan, the patients in the hospital will do better than they did before.”

Duration of Antibiotics

- Prospective observational study
- Adults with *complicated appendicitis*
  - 3 days antibiotics (n=75)
  - 5 days antibiotics (n=191)
    - IV only / IV + PO
- Outcomes similar:
  - SSI (p=0.89)
  - Intra-abdominal abscess (0.81)
- 3 day group had shorter hospital LOS
- Surgeon diagnosis of “complicated” did not match pathology in 55%
  - Only surgical diagnosis was independent predictor of infectious complications

Do we need post-op antibiotics at all?

- 410 adults with *complicated appendicitis*
  - Pre-operative antibiotics only (n=136)
  - Post-operative antibiotics (n=274)
    - All baseline characteristics statistically similar

- Outcomes statistically similar (p>0.05):
  - Superficial SSI
  - Deep SSI
  - Readmission

- Hospital LOS shorter in no-abx group (p=0.004)
  - Median 4 vs 5 days

- Missing: comparison of % perforated in each group

Unaddressed

• Diagnostic work-up
  – Physical Exam vs Ultrasound vs CT scan
  – Labs

• Type of antibiotics to use
  – May need to be tailored to specific patient population
  – Involvement of ID colleagues

• Optimal categories to use
  – Simple vs complicated?
  – Simple vs gangrenous vs perforated?
Summary

• Clinical pathways work!
  – Decrease resource utilization
  – Reduce costs
  – Minimize complications
  – Improve outcomes

• Appendicitis particularly well suited to management via clinical pathway
  – Evidence that it works
  – Common problem
  – Relatively predictable course
Summary

• Not a cure-all
  – Must always be prepared to break away from pathway