The 5 W’s of Failure of Non-operative Management of Solid Organ Injury in Children

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Background

- Nonoperative Management has become standard in pediatric trauma
- Failure of NOM still occurs
- Time to start asking questions
Failure of NOM of SOI in children: 5 W’s

- Who Fails
- What predicts failure
- When do they fail
- Where are they fail?
- Why did they fail?
Who fails?

Not very many

- Overall failure rate 5% has been reported
- [9% to 15%, isolated injuries]
  - Pancreas 18%
  - Spleen 4%
  - Liver 3%
  - Kidney 3%


Who fails? By mechanism

- Bicycle crashes = significantly increased risk (RR = 1.76)
- Falls less likely to fail (0.16)
- MVC, MCC, sports, assaults = average

Holmes, James; Wiebe, Douglas; Tataria, Monica; Mattix, Kelly; Mooney, David; Scaife, Eric; Brown, Rebeccah; Groner, Jon; Brundage, Susan; Tres Scherer, L; Nance, Michael. Journal of Trauma-Injury Infection & Critical Care. 59(6):1309-1313, December 2005.
What predicts failure?

**Predictive**
- Higher grade 4 (5x), 5 (58x)
- ISS > 25 (15x)
- GCS</=8 (5x)
- Multiple injuries (4x)

**Not Predictive**
- Grade 1-3 (no increases)
- age*
- gender

Holmes, James; Wiebe, Douglas; Tataria, Monica; Mattix, Kelly; Mooney, David; Scaife, Eric; Brown, Rebeccah; Groner, Jon; Brundage, Susan; Tres Scherer, L; Nance, Michael. Journal of Trauma-Injury Infection & Critical Care. 59(6):1309-1313, December 2005.
What predicts failure?

Predictive

- Hypotension at admission
- Transfusions
- HAE
- Peritonitis at first exam
- Initially Hb <8.5 g/dl
- Large hemoperitoneum
- **Hypotension without preoperative transfusion

<table>
<thead>
<tr>
<th>Predictive</th>
<th>Not predictive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Absence of contrast material in the ipsilateral ureter</td>
<td>The diameter of extravasation</td>
</tr>
<tr>
<td>Large separation of the upper and lower poles</td>
<td>Location of extravasation</td>
</tr>
<tr>
<td>Multiple areas of extravasation</td>
<td></td>
</tr>
<tr>
<td>Transfusion</td>
<td></td>
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</tbody>
</table>

What predicts failure?

Pancreas

- Patients with an injury of grade III to V are more likely to “fail” NOM

- More later...

When do children fail?
Figure 1. Time from admission to laparotomy (failure of observation) expressed as number of patients within each time period. One-third of the patients had nonoperative management that failed within 12 hours of admission, 60% within 24 hours of admission.

When? Timing of NOM Failure

- Median time to failure
  - 3 hours
  - 40% having failed by 2 hours
  - 60% by 4 hours
  - 75% by 12 hours


Fig. 1. Smoothed hazard function curves showing failure rates over time for the entire study population (solid line), and after excluding patients who failed NOM within 3 hours of admission (dashed line).
Where?
Where?

- Several studies find outcomes for adult trauma centers are the same as pediatric trauma centers.
- **Teen trauma without the drama**: Outcomes of adolescents treated at Ohio adult versus pediatric trauma centers.
- Concluded- Similar outcomes....Similar LOS/ICU/Survival.
- Did not include failure of NOM as an outcome.

Where?

- Studies looking at failure of NOM:
  - Pennsylvania Trauma Systems Foundation database
    - Age 13 to 18 years; 2005 to 2010
    - Multivariable regression models
    - PTCs → Less frequent emergent laparotomy for all patients (OR, 0.65; P = 0.007)

Where do they fail?

- United States – 27 states; 80,000 pts
- Pediatric Spleen Injury
- Odds Ratio for Splenectomy
  - Trauma Center vs. Non-Trauma Center - 2:1
  - General Hospital vs. Children’s Hospital – 2.8:1
  - General Surgeon vs. Pediatric Surgeon – 4:1
  - Adult Center vs. Pediatric Trauma Center – 6:1

Where do they fail?

- JAMA; Ages 0-16y; 2800 children
- Adjusting for
  - patient characteristics
  - injury severity
  - hospital characteristics
- Risk of Splenectomy 5x higher at adult vs children's hospitals

Why?

- Why do children fail NOM?
Why? Common causes

1. Shock
2. Peritonitis
3. Continued Bleeding
4. Intestinal injury
5. Pancreatic injury
6. Diaphragm injury

Why?

- Less common causes
  - Intraabdominal compartment syndrome
Why? Liver

- Intrahepatic bile duct leaks
- Duodenal obstruction by hypertrophy of the left lobe of the liver
Why? Renal

- Hemodynamic instability
- Persistent bleeding
- UPJ disruption
- Abscess
- Clot retention

Hemodynamic instability 11%
Symptomatic urinoma 3%
Percutaneous or ureteral stenting 14%

Why? Higher grade kidney

Why? Peritonitis

- Those with intestinal injury need surgery
- Concern for intestinal injury
  - Once argument against NOM
- Several multicenter studies
- No need for urgent exploration when the diagnosis is in question
Why? Peritonitis

- No correlation between time to surgery and complication rate
- Delay not associated with an increase in LOS
- Appropriate observation and serial examination

Why? Continued bleeding
Why? Bleeding

- Splenic blush
  - In adults = embolize
- In children
  - Routine SAE doesn’t improve salvage
  - Alternative to splenectomy


Why? Bleeding

- 6.5% had CE on initial CT
- No association between “blush” and...
  - Splenectomy
  - Delayed splenic bleeding (DSB)
  - Mortality
  - LOS
  - Need for transfusion
- In children, CE on abdominal CT
  - not associated with negative outcomes

Why? Continued bleeding; not Re-bleeding

- 14 pediatric cases of DSB reported in the literature since 1980.
  - mean age 14 years +/- 4 years
  - 7 of the cases are not DSB, but delayed presentations

Why? Delayed splenic bleed

- Mean time to DSB was 10 days +/- 7 days

### APSA Guidelines for LOS

<table>
<thead>
<tr>
<th>Grade</th>
<th>LOS</th>
</tr>
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<tbody>
<tr>
<td>Grade 1</td>
<td>2 days</td>
</tr>
<tr>
<td>Grade 2</td>
<td>3 days</td>
</tr>
<tr>
<td>Grade 3</td>
<td>4 days</td>
</tr>
<tr>
<td>Grade 4</td>
<td>5 days</td>
</tr>
<tr>
<td>Grade 5</td>
<td>6 days</td>
</tr>
</tbody>
</table>

- According to the APSA guidelines
  - 10 days hospitalization → identify half of the DSBs
Why? Re-bleeding

- Delayed Splenic Bleeding (DSB)
  - 1 of 303 (0.33%) children with blunt splenic injury
    - Patient – 15y M
    - Grade IV injury
    - Presented 23 days after initial injury with DSB causing death.


- 1 of 606 (0.16%) children with blunt splenic injury
Why? Pseudoaneurysms
16 Studies in children

Fig. 1 Management and outcomes of posttraumatic SAPs after blunt splenic injury.

Why? Hepatic artery pseudoaneurysm

- 1.7% of liver injuries developed pseudoaneurysms
- All associated with grade IV injuries
  [Grade IV 27% → pseudoaneurysms]
- 1 underwent early embolization
- 2 developed delayed hemorrhage requiring emergent treatment

Why? Liver pseudoaneurysm

- Few cases (recall – only 3% fail)
- 15 cases of HAE for pseudoaneurysm
- Generally successful

Why? Liver Pseudoaneurysm
Different than spleen

- Rarer
- Delayed life-threatening bleeding appears to be more common than splenic pseudoaneurysm
- Literature suggests HAPs are more serious than SAPs
Why? Liver

- ERCP, PTC, and CT drainage manage most complications.
Why? Pancreas

- Blunt pancreatic trauma tends to require operative intervention more frequently than any other SOI
- NOM failure rate of 16-26%
Which pancreatic injuries can be managed non-operatively?

- AAST Grade 1
  - Non-operative
- AAST Grade 2
  - Also non-operative

<table>
<thead>
<tr>
<th>Grade</th>
<th>Injury</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>I</td>
<td>Hematoma</td>
<td>Minor contusion without duct injury</td>
</tr>
<tr>
<td></td>
<td>Laceration</td>
<td>Superficial laceration without duct injury</td>
</tr>
<tr>
<td>II</td>
<td>Hematoma</td>
<td>Major contusion without duct injury or tissue loss</td>
</tr>
<tr>
<td></td>
<td>Laceration</td>
<td>Major laceration without duct injury or tissue loss</td>
</tr>
</tbody>
</table>
# Pancreas Injury Scale

<table>
<thead>
<tr>
<th>Grade</th>
<th>Type of Injury</th>
<th>Description of Injury</th>
<th>ICD-9</th>
<th>AIS-90</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Hematoma</td>
<td>Minor contusion without duct injury</td>
<td>863.81-863.84</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Laceration</td>
<td>Superficial laceration without duct injury</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>II</td>
<td>Hematoma</td>
<td>Major contusion without duct injury or tissue loss</td>
<td>863.81-863.84</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Laceration</td>
<td>Major laceration without duct injury or tissue loss</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>III</td>
<td>Laceration</td>
<td>Distal transection or parenchymal injury with duct injury</td>
<td>863.92/863.94</td>
<td>3</td>
</tr>
<tr>
<td>IV</td>
<td>Laceration</td>
<td>Proximal? transection or parenchymal injury involving ampulla</td>
<td>863.91</td>
<td>4</td>
</tr>
<tr>
<td>V</td>
<td>Laceration</td>
<td>Massive disruption of pancreatic head</td>
<td>863.91</td>
<td>5</td>
</tr>
</tbody>
</table>

*Advance one grade for multiple injuries up to grade III. *863.51,863.91 - head; 863.99,862.92-body;863.83,863.93-tail. aProximal pancreas is to the patients’ right of the superior mesenteric vein. From Moore et al. [6]: with permission.

http://www.aast.org/Library/TraumaTools/InjuryScoringScales.aspx
#pancreas
Why? Pancreatic NOM

- The distal pancreatectomy group
  - Quicker to goal feeds 8 days vs 15 days (p=0.01)
  - No pseudocysts (vs 18% in non-op)
  - Fewer endoscopic (2% vs 21%, p=0.01)
  - Fewer interventional radiologic procedures (0% vs 18%, p=0.03)

Why? Pancreatic NOM

- Non-operative management of pancreatic injury is possible
- Failure rates and complications are high with non-operative management
- Grade 3, 4, 5 injuries appear to do better if managed operatively

Why?...or what can we do to prevent failure
Why do they fail? Adults

“written protocols, better adherence to sound clinical judgment...would reduce the incidence of failure of nonoperative management of blunt splenic injury in adults”

Why?

- Pediatric Guidelines
  - Stylianos/APSA - goal
  - Arkansas – Smith – treatment on hemodynamic status
  - Kansas – St Peter
  - ATOMAC
Guidelines

- Practice guideline
  - ATOMAC - 6 Trauma Medical Directors
    - Adopted by >10 Level I Pediatric Trauma Centers
- Goal – improve NOM success
Fig. 1  Treatment algorithm for isolated blunt spleen and liver injuries based on hemodynamic status.
Non-operative Management
Pediatric Liver & Spleen Injury
The ATOMAC Guidelines

1. Follow ATLS protocol first.
2. Patients with peritonitis are managed per surgeon discretion. Do not use this algorithm for patients with peritonitis.
3. Guideline was based on pediatric studies with younger patients, so use caution in patient 16 or older.
4. May be used for polytrauma patients where not contraindicated.
5. Continued bleeding is defined by the surgeon. Examples: inadequate Hb increase to transfusion, hemodynamic signs of hypovolemia +/- anemia.
6. "Stable Hb" means a Hb value not dropping more than 0.5mg/dL in 12hrs. Repeat Hb at 24hrs is optional.
7. Any lab suspected to be erroneous may be repeated prior to medical decision-making.
8. Times refer to the time of injury.
9. Late presentation: Stable patients presenting within 48hrs post injury are still admitted for observation (18 hours), but Hb rechecks are optional. Injuries >48hrs are at surgeon discretion.
10. Embolizing CT blush may be considered.
11. Interventional modalities such as ERCP, laparoscopy, angiography, or percutaneous drainage may be required to manage complications of bile leak or hemobilia.

**Discharge Instructions**
No ibuprofen or other NSAIDS.
Acetaminophen is okay.
May go back to school when off pain meds.
Restricted activity for length per APSA Guidelines (grade 2 = weeks).
Return to ED for increasing pain, pallor, dizziness, vomiting, worsening shoulder pain, GI bleeding or black tarry stools. Call office for jaundice.
Phone call follow-up for grade 1-2 injury at 2 weeks and again at 60 days.
Office visit for Grade 3-5 injury at 2 weeks.
Phone call at 60 days post-injury.
No follow-up imaging is required. Imaging is optional.

Liver or Spleen Injury
By CT scan
(or suspected injury)

No signs of ongoing bleeding

Stable

Type and Screen
Admit to non-ICU
Vitals q2h x 4, then q4h
Bedrest overnight
Hb at 6, 12, and (optional) 24hrs

Hb < 7.0 or symptomatic

Non-responder to PRBCs

Surgery

Continued bleeding

CT if not already done
Admit to PICU
Vitals per ICU routine
NPO
Hb q6h
Bedrest until Hb stable
Interventions as indicated

Stabilized

Hb < 7.0 or symptomatic

No bleeding for 24 hrs.
Transfer to floor not contraindicated by other injuries.

10mL to 30mL/Kg PRBC
NPO
Bedrest x 24hr
Hb q6h
Consider embolization

Hb or vital signs still unstable
After >40mL/Kg PRBCs
or >4 units PRBCs

Failure of NOM Algorithm

Rebleed or Continued bleeding

Angiography and embolization if available

Surgery

Continued NOM at surgeon discretion

Hb Stable
Conclusion

- **Who fails:** Not many. Age and gender don’t matter, pancreas and grade do.

- **What predicts failure:** Bicycles, hypotension, non-responders, high ISS, low GCS

- **When do they fail:** Earlier than adults, typically 2 hours

- **Where?** Non-pediatric trauma centers, centers with non-pediatric surgeons

- **Why?** Continued bleeding, peritonitis, pancreatic injury, bowel injury; not delayed bleeding. Lack of a protocol
Thank you