Pediatric Solid Organ Injury

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Case 1

7 yo healthy boy
flown in to LEMC as level II trauma activation after dirt bike accident
Travelling ~25mph and crashed head-on into another dirt biker, handlebars struck abdomen
+LOC (~30 sec), several episodes of emesis
Complaining of severe abdominal pain

Primary Survey

A: awake and talking
B: unlabored respirations, equal/bilateral breath sounds
C: 2+ peripheral pulses, RRR

Visit Vital
- BP
- Pulse
- Temp
- Resp
- SpO2

110/65
102
36.8 °C (98.2 °F) (Oral)
20
100%
Secondary Survey

- Minor facial ecchymosis
- Abdominal exam: tender to palpation, worst in the RUQ and RLQ, no peritoneal signs

Labs

**CBC and Differential**

- WBC: 15.3
- RBC: 4.32
- Hemoglobin: 12.8
- Hematocrit: 36.5
- BUN: 62
- Cr: 26.0
- Bilirubin: 26.4
- BNP: 12.9
- Procalcitonin: 297
- PTT: 10.3
- APTT: 12.0
- D-Dimer: 2.75
- SUV: 8.93
- ALT: 8.01
- AST: 6.82
- ALK Phos: 76
- ALP: 12.5
- Na: 139
- K: 3.9
- Ca: 8.5
- Mg: 2.3

**GENERAL CHEMISTRY**

- Sodium: 141
- Potassium: 2.6
- Cholesterol: 180
- Carbon Dioxide: 20
- Creatinine: 0.44
- Glucose: 145
- Calcium: 8.5
- Total Protein: 6.5
- Albumin: 3.9
- Sedimentation Rate: 30
- Liver function tests: Normal

**Case 1**

PICU admission

- Hct q6h until stable for 2 values
  - 35.6 -> 34.1 -> 33.9
  - Mild tachycardia resolved

- Transferred to ward HD 2
- Discharged home HD 3 with 5 week activity restrictions

Liver laceration
Solid abdominal organ injury

8-12% of children with blunt trauma will have an abdominal injury

>90% children with blunt abdominal injuries survive

Abdominal injuries
- 30% more common than thoracic injuries
- 40% less likely to be fatal

Liver and Spleen

Most commonly injured organs in blunt abdominal trauma

Non-operative management in stable patient is standard of care

IMAGING

CT - imaging study of choice for hemodynamically stable patient

<table>
<thead>
<tr>
<th>Test</th>
<th>Dose (mSv)</th>
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<tbody>
<tr>
<td>Chest x-ray</td>
<td>0.1</td>
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<tr>
<td>Pelvis x-ray</td>
<td>0.1</td>
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<tr>
<td>CT Head</td>
<td>2</td>
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<tr>
<td>CT Cervical spine</td>
<td>3</td>
</tr>
<tr>
<td>Plain c-spine</td>
<td>0.2</td>
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<tr>
<td>CT Chest</td>
<td>7</td>
</tr>
<tr>
<td>CT Abdomen/pelvis</td>
<td>10</td>
</tr>
<tr>
<td>CT T&amp;L spine</td>
<td>7</td>
</tr>
<tr>
<td>Plain T&amp;L spine</td>
<td>3</td>
</tr>
</tbody>
</table>

Image gently

FAST

Focused Assessment with Sonography in Trauma (FAST)
- First used in 1996
- Rapid, Accurate
- Sensitivity 86-99%
- Can detect 100 mL of blood
- Cost-effective
- Four different views: Pericardiac, Perihepatic, Perisplenic, Peripelvic space
- Eliminates unnecessary CT scans
- Helps in management plan

FAST exam:
Morrison’s pouch
Pouch of Douglas
left flank
pericardial view

Scaife et al 2013: sensitivity 50%, specificity 85% for detecting free fluid, sensitivity for injuries requiring operation or transfusion was 87%
Liver and Spleen

APSA (American Pediatric Surgical Association) Trauma Committee analyzed 832 children treated non-operatively at 32 centers in North America 1995-1997

<table>
<thead>
<tr>
<th>AAST Liver Injury Scale (1994 revision)</th>
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<tr>
<td>Grade</td>
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<td>IV</td>
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<tr>
<td>V</td>
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<tr>
<td>Vascular</td>
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</table>

APSA Guidelines

312 children with liver or spleen injuries treated non-operatively at 16 hospitals 1998-2000, analyzed for compliance with guidelines

Compliance rates: 81% ICU stay, 82% hospital stay, 87% follow-up imaging, 78% activity restriction

6 patients readmitted, none required operation

When compared to 832 original patients, significant reduction in ICU stay, hospital stay, follow-up imaging, physical activity duration
Mehall et al 2001  
Arkansas Children’s Hosp

1996-1999, 44 hemodynamically stable pts with liver/spleen injuries (89 total pts with liver/spleen injuries, most excluded for GCS<13)

Admitted to the ward and managed according to hemodynamic stability without using CT grade

Management for hemodynamically stable patients

All managed non-operatively without blood transfusion
One patient did not complete algorithm due to early biloma formation
LOS significantly shorter than predicted by APSA guidelines (1.9 vs. 3.5 days p<0.001)
1 month f/u with ultrasound, no delayed bleeds, 1 splenic pseudoaneurysm

Nonoperative management

- Current standard of care for pediatric solid organ injury – failure rates reported at 5%
- Common practice = APSA – ‘Grade+1’ protocol
- Next step – minimize variance, maximize hospital resources – with a hemodynamic-driven protocol

2. Holmes et al. J Trauma. 2005
3. Mehall et al. JACS. 2001
Minimizing variance in care of pediatric blunt solid organ injury through utilization of a hemodynamic-driven protocol

**Protocol**

**Solid Organ Injury Protocol**

- **Hemodynamically stable**
  - Normal VS
  - Tachycardia due to low Hct
  - Admit ICU
  - VS Q1 hrs x 4 then Q4 hrs
  - NPO
  - Bathroom privileges
  - Check Hct Q6 hrs
  - VS stable x 12 hrs
  - Check Hct

- **Unstable Hct**
  - Recheck Q6 hrs
  - Consider ICU transfer if VS change

- **Stable Hct**
  - Regular diet
  - Ambulate
  - DC home after another 8 hrs
  - VS Q1 hrs x 4 then Q4 hrs
  - NPO
  - Bathroom privileges

- **Unstable**
  - Recheck Q6 hrs
  - Consider ICU transfer if VS change

*From Mehall et al. 2001*

**Methods**

- Patients fitting criteria were examined in a retrospective cohort study
- Control period – July 2013-Dec 2014
- All solid organ injuries (liver, spleen, kidney) presenting to two children’s hospitals
- Records analyzed for age, sex, ISS, grade of injury, LOS, time in ICU, phlebotomy, compliance with protocol, NSQIP-defined complications, re-admission and cost.
- Exclusion criteria: immediate surgical or radiologic intervention
Demographics

<table>
<thead>
<tr>
<th>Control</th>
<th>Protocol</th>
<th>p-value</th>
<th>NS</th>
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<tbody>
<tr>
<td>Age (y)</td>
<td>8.11</td>
<td>7.57</td>
<td>0.468</td>
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<tr>
<td>Male</td>
<td>38 (69%)</td>
<td>36 (73%)</td>
<td>--</td>
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<tr>
<td>ISS</td>
<td>16.47</td>
<td>16.30</td>
<td>0.467 NS</td>
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<tr>
<td>Average Grade of Injury</td>
<td>2.53</td>
<td>2.90</td>
<td>0.105 NS</td>
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Injuries by Grade and Organ

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<thead>
<tr>
<th>Organ</th>
<th>Grade 1</th>
<th>Grade 2</th>
<th>Grade 3</th>
<th>Grade 4</th>
<th>Grade 5</th>
<th>Total</th>
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<tbody>
<tr>
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<td>8</td>
<td>5</td>
<td>1</td>
<td>1</td>
<td>1</td>
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<tr>
<td>Spleen</td>
<td>5</td>
<td>8</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>15</td>
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<tr>
<td>Kidney</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
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<td>Total</td>
<td>14</td>
<td>15</td>
<td>1</td>
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<td>1</td>
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Control

<table>
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<tbody>
<tr>
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<td>Liver</td>
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<td>Spleen</td>
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<td>3</td>
<td>Kidney</td>
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<td>4</td>
<td>Total</td>
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Protocol

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<td>14</td>
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<tr>
<td>4</td>
<td>Total</td>
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Average Grade of Injury

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<tr>
<td>2.53</td>
<td>2.90</td>
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Results

<table>
<thead>
<tr>
<th>Length of Stay (hours)</th>
<th>Control</th>
<th>Protocol</th>
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<tr>
<td>1.91</td>
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<table>
<thead>
<tr>
<th>Days in ICU (days)</th>
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<td>1.91</td>
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<table>
<thead>
<tr>
<th>Blood Draws (#)</th>
<th>Control</th>
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<tr>
<td>7.73</td>
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<table>
<thead>
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<th>Hospital Cost ($)</th>
<th>Control</th>
<th>Protocol</th>
<th>p = 0.078</th>
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<tr>
<td>11699.38</td>
<td>8609.58</td>
<td>8609.58</td>
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Data Summary

- Compliance with protocol 81.6%
- NSQIP-defined complications: 2.8% (2/3 unrelated to SOI management)
- Post-hoc analysis: No late failures (>12 hours) of SOI protocol
- Mean hospital cost $8609 represents >$4000 in savings from mean pediatric SOI cost of $12,704 by Dodgion et. al

Conclusions

- Hemodynamic-driven, SOI protocol is safe and reduces the use of hospital resources
- Absence of protocol failures implies that further efficiency could be achieved with earlier transfer from ICU, less phlebotomy, and earlier discharge

Case 2

9 y.o boy hit tree stump with his flank, while sledding
c/o left flank pain
Taken to another hospital
Had one episode of gross hematuria
Had a CT scan of abdomen

Exam

Vitals  HR- 70s, SBP 120s, O2 sat mid 90s on RA
GCS 15
CTA B
Soft, L flank bruising and discomfort
no guarding or rebound
No Blood at the meatus

Renal injury
Hospital Course

T & C sent
Admitted to PICU for serial exams and Hct
HCT- nadir at 30, then increase to 34
No further gross hematuria, microscopic hematuria persisted
L sided discomfort improved
D/C home PID # 4

Discussion

Kidney frequently injured in pediatric blunt abdominal trauma
90% are blunt injuries
- 10-20% of all injuries
- Lack of perirenal fat
- Relative large size of kidney to body
- More pliable rib cage

Renal injury grading

I- Microscopic hematuria, or subcapsular non expanding hematoma
II- non expanding hematoma confined to retroperitoneum
  - <1cm parenchymal laceration w/o urinary extravasation
III- >1cm laceration of cortex and medulla, spares collecting system
IV- Renal artery or vein damage
V- Completely shattered kidney, or avulsion of hilum

Initial Assessment

1. Hemodynamic stability
2. Type or Mechanism of Trauma
   - Blunt Vs. Penetrating
   - Deceleration Injuries
3. Associated nonrenal injuries
4. Hematuria
5. Clinical examination
Management

Bed rest and ICU Monitoring for 24-48hr

Serial HCTs

Any HD instability or a drop in Hct unresponsive to 3U PRBC showed prompt repeat CT and possible exploration

Most bleeding will occur in 48 hrs

Bed rest until gross hematuria resolves

Ambulation without return of hematuria prior to d/c

Imaging for renal injury

Routine re-imaging at 48 hours.

Routine reimagining at 1-3 months to show resolution and healing

Conclusion

Repeat imaging for grade III and higher blunt renal injuries is justified for identification of complications in patients with grade 3 injuries or higher

Case 3
6 yo boy
Fell while riding his bike
Hit his abdomen with the handlebars
Taken to outside hospital
Reportedly hypotensive
Transferred to EH

When nonoperative management fails
SBP 70-100
HR 80-120
Awake and alert
Complaining of abdominal pain
tender in LUQ
Warm, 2+ DP bilaterally

Next steps in management?
Imaging?
Labs
Fluids
  • Bolus
  • blood

Abdominal CT
Management
Admitted to the PICU
Serial Hct
Foley
A line
bedrest

Hospital course
He continued to have bouts of hypotension to a systolic of 70
> Associated with lethargy
Received 60 ml/kg crystalloid and 20 ml/kg of PRBC
Responded to bolus but dropped when infusion stopped
SBP dropped to 45
> Unresponsive
> Fluid bolus, PRBC
> To OR

Operative management
OR
> Spleen in two pieces
> Oozing but no active hemorrhage
> Devascularized segment removed
> Biogluue applied to remaining spleen

Hospital course
Did well after surgery
Tolerated a diet
D/C’d to home
Decision to Operate

- Successful non-operative management >90%
- Decision made due to hypotension, tachycardia, decreased UOP, decreased Hct, not responding to transfusions
- Angioembolization can be considered but is used less commonly in children than adults
- Hemostatic maneuvers: manual compression, suture, topical agents

Complications of non-operative management

- Delayed hemorrhage: rare anecdotal reports, potentially fatal
- Splenic pseudoaneurysm: often asymptomatic and resolves on its own

Complications of non-operative management

- Splenic pseudocyst: Can grow quite large and cause pain and GI symptoms
  - High rate of recurrence with simple aspiration
  - Effective treatment is excision and marsupialization

One multi-institutional review showed operation required in 120/1813 (6.6%) patients
- Median time to surgery 2.4 hours
- 90% of operations within 24 hours
- Predictors of failure of non-operative management:
  - High ISS, Severe head injuries (GCS<9), bicycle mechanism, multiple solid organ injuries, grade V solid organ injury
Complications of non-operative management

Bile duct injury: 4% risk of persistent bile leakage
  - Dx with HIDA scan
  - Tx: ERCP with stenting

Questions
1. Solid organ injury is the most common traumatic injury in children?
   - A. True
   - B. False

Conclusions

• Overall how do we manage patients with solid organ injury?
  – PICU/ward
  – Angio/OR
Questions
1. Solid organ injury is the most common injury in children with blunt trauma?
   - A. True
   - B. False
   **Answer:** False.

2. 8-12% of children suffer solid organ injuries after blunt trauma
   - A. True
   - B. False
   **Answer:** True.

3. Head injuries
   - A. True
   - B. False
   **Answer:** True.

4. Fractures more common
   - A. True
   - B. False
   **Answer:** True.

Question 2
1. Children with solid organ injury require a transfusion for a HCT of?
   - A. 25
   - B. 21
   - C. any with hemodynamic instability
   - D. B and C
   **Answer:** B and C.

D. Transfusion should be performed when HCT <21 or when patient remains hypotensive after an initial fluid challenge

Question 3
Nonoperative management of children with solid organ injuries is successful 90% of the time
- A. True
- B. False
   **Answer:** True.
Nonoperative management of children with solid organ injuries is successful 90% of the time.

A. True

Protocolization of the care for children with solid organ injury has led to successful nonoperative management in children 90% of the time.

B. False

What are indications for children with abdominal trauma to undergo a CT scan to rule out solid organ injury?

A. Hemodynamically stable children
B. All children with abdominal tenderness
C. Tenderness with elevated LFTs
D. Hemodynamically unstable children

Complications of nonoperative management include the following?

A. Bile leaks
B. Splenic pseudocyst
C. Urine leak
D. All of the above
Question 5
Complications of nonoperative management include the following?
A. Bile leaks
B. Splenic pseudocyst
C. Urine leak
D. All of the above.

The most common complications of solid organ injuries include bile leaks (liver), splenic pseudocyst (spleen) and urine leak (kidney).