Pediatric Solid Organ Injuries: Waiting/Watching and Beyond

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ABDOMINAL INJURIES –
The “Cutting Edge” or Watchful Waiting?

OBJECTIVES

➢ Review epidemiology and pathophysiology of abdominal injury in children
➢ Discuss major issues that arise with nursing and medical management of the child with abdominal injury
➢ Analyze cases demonstrating facets of solid organ injury
CASE

- Heart rate 140, BP 100/70; alert, crying off and on

CASE

- WHAT ARE YOUR CONCERNS?
  - ABDOMINAL INJURY
  - SHOCK
- HOW WILL YOU PREPARE?
  - OXYGEN
  - IV FLUIDS
  - NG TUBE
- WHAT DO YOU ANTICIPATE FOR LABS, IMAGING, AND DISPOSITION?
  - Liver enzymes, CBC, clotting parameters; FAST/CT abdomen; floor vs PICU

REVIEW OF ABDOMINAL ANATOMY
CHILDREN ARE NOT SMALL ADULTS

- Protruberant abdomen
- Small ribcage
- Little fat
- Underdeveloped pelvis

Anatomic Considerations:
- Close proximity of multiple organs
- Solid organs larger compared to rest of abdomen
- Less connective tissue, less muscle mass
- Bony skeleton incompletely ossified
Anatomic Considerations:

- Rib cage is higher and more pliable; rib fractures uncommon (require massive force)
- Smaller body mass sustains greater force per unit body area; ↑ likelihood of multiple injuries

ABDOMINAL INJURIES

- Usually blunt in children
  - Handlebars, trees, falls, playground equipment, kicks by animals or humans, seatbelts
ABDOMINAL CONTENTS
- Liver, spleen extremely vascular
- Stomach, intestine, colon - hollow viscus; filled with digestive products and bacteria
- Pancreas – secretes enzymes
- Kidneys – vascular; vital functions
- Adrenal gland – hormone production
- Bladder, ureters, urethra – storage and transit

SIGNS AND SYMPTOMS OF INJURY
- Bruising
  - Note location, consider underlying structures
- Distension; rigidity
- Pain
  - Have child point with one finger
  - Note quadrant
  - Light or deep palpation

SIGNS AND SYMPTOMS
- Nausea/vomiting
  - May be general response to stress of trauma, to head injury, or specific to abdominal injury
- Difficulty or pain on voiding
  - Assess for hematuria
- Check back for abrasions, bruising, tenderness!
ED MANAGEMENT

- Airway, breathing
  - O2 always appropriate – increased metabolic needs
- Circulation
  - IVF; bolus 20 mg/kg to maintain perfusion
- +/- NG/OGT to decompress stomach; check for blood or bile

ED MANAGEMENT

- Urinary catheter to check for flood and urinary retention IF no blood at meatus.
  - Urethrogram if necessary
  - UA: microscopic blood not usually cause for concern
- NPO until labs back, exam normal, decision for non-op management

FURTHER ASSESSMENT

- Vital signs
  - Blood pressure
  - Tachycardia, dyspnea or tachypnea
- Labs
  - CBC
  - ALT, AST, ggTP, alk phos, lipase, amylase, PT/PTT/platelets
  - BUN, creatinine, lytes
FURTHER ASSESSMENT

- **FAST** *(Focused Assessment with Sonography in Trauma)*
  - 15% false negative; quick, noninvasive

- **CT scan**
  - Usually done with and without contrast
  - View bone, soft tissue, fluid

- *(Diagnostic Peritoneal Lavage)*

Clinical Presentation:

- Abdominal pain / tenderness
- Right or left shoulder pain
- Often have associated injuries
  - CNS most common (34%)
- Shock AST / ALT > 250 indicative of liver injury
- Diagnosis: CT scan; Graded I-V

REVIEW...

- Which is the most commonly injured abdominal organ?
- What is the first sign of significant internal bleeding in a child?
- Which labs are typically obtained in initial assessment of the child with abdominal trauma?
BACK TO OUR PATIENT...

- Diagnosed with grade 3 splenic laceration
- Stabilized in the ED and admitted to floor
  - What care does he need? Surgery? Bedrest? NPO? Follow up CT scans or US?

AAST Injury Scale

<table>
<thead>
<tr>
<th>CT GRADE</th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
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<tbody>
<tr>
<td>Days in ICU</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>1 day</td>
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<tr>
<td>Hospital stay</td>
<td>2 days</td>
<td>3 days</td>
<td>4 days</td>
<td>5 days</td>
</tr>
<tr>
<td>Pre-discharge imaging</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Post-discharge imaging</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Activity restrictions</td>
<td>3 weeks</td>
<td>4 weeks</td>
<td>5 weeks</td>
<td>6 weeks</td>
</tr>
</tbody>
</table>

Liver lac and shattered spleen
SHOCK

- In trauma, caused by
  - Blood loss
  - Myocardial dysfunction
  - CNS or spinal cord-related hypotension

CELLULAR CONSEQUENCES OF SHOCK

- Inadequate oxygen and substrates to cells
- Anaerobic metabolism
- Inadequate removal of by-products
- Fluid losses into tissues
HYPOVOLEMIC SHOCK

- Lethal triad:
  - Acidosis - lactate signifies anaerobic metabolism. Indicator of tissue hypoperfusion. Base deficit is surrogate marker.
  - Coagulopathy
    - All are present in patients who present with significant bleeding; markers for mortality

LIVER VS. SPLEEN INJURIES

- As opposed to adults, children with spleen injuries rarely require transfusion or splenectomy
- If not responding as expected, consider bleeding, splenic disorders
  - Liver is the second most commonly injured organ from blunt abdominal trauma
  - The rich blood supply of the liver leads to more severe hemorrhage; more likely to require operative intervention than splenic injury
MANAGEMENT OF SEVERE LIVER AND SPLEEN INJURIES

- Transfusion
  - Massive transfusion protocol:
    - 4 U RBC, 4 U plasma, 1 U platelets; blood bank prepares another set
  - Safety of uncrossmatched blood = that of crossmatched blood in > 95% of patients.

OPERATIVE INDICATIONS:

- Hemodynamic instability
- Clinical deterioration
- Associated hollow viscus injury
- Transfusion requirement ??

[Image: Indications for Red Cells in the ICU]

"A multicenter, randomized, controlled clinical trial of transfusion requirements in critical care"
- 838 Critically-ill pts.; evaluated after initial treatment
- acute hemorrhage excluded due to ethical considerations
- Hgb < 9 gms/dl within 72 hrs of ICU admission

Restrictive Strategy
- 63 pts.
- Transfused if Hgb fell below 10 gms/dl.
- Maintained at 7-9 gms/dl.

Liberal Strategy
- 623 pts.
- Transfused if Hgb dropped below 10 gms/dl.
- Maintained at 10-12 gms/dl.

Herbert, et al., NEJM, Feb 1999
Operative Intervention for spleen:
- Splenorrhaphy
- Partial Splenectomy
- Splenectomy

Overwhelming Post-splenectomy Infection:
- Spleen filters bacteria; produces IgM and assists T/B cell function
- Lifetime risk is 350-fold for all pediatric trauma patients after splenectomy – less for trauma than hemoglobinopathes
- 50% mortality; greatest risk in first 1 year

Overwhelming Post-splenectomy Infection
- Controversy on prophylactic PCN (little evidence)
  - May be given for (at least) 1 year
  - May be stopped at age 5 years
- Vaccinations: Pneumococcus, H. influenza, Meningococcus, annual flu
  *vaccine*: http://aapredbook.aappublications.org/content/
- Education re: early evaluation for illness
- **Preoperative Management for hemorrhage**
  - rapid infuser is a must
  - Venovenous ECMO optional adjunct

- **Intraoperative Management**
  - “Damage control” surgery
  - Abbreviated lap for exploration, control of hemorrhage and contamination, packing, temporary abdominal closure (vac or silo)

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**DAMAGE CONTROL SURGERY**

- Allows for aggressive ICU resuscitation: Core rewarming, volume and oxygen, correction of coagulopathy
- Planned reoperation for packing change and eventual abdominal closure
- Concerns: Intraabdominal sepsis, organ failure, increased intraabdominal pressure related to IVC compression, hypoperfusion
  - Bladder pressure monitoring

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**NURSING CARE FOR LIVER, SPLEEN, & KIDNEY INJURIES**

- Clinical effectiveness guidelines - Address monitoring of H&H, diet, activity
- Positioning – semi-Fowler’s/HOB up
- Incentive spirometer or bubbles!!!!
- Pleural effusion is common complication – Cilley, Rucydlo
ACUTE AND FOLLOW UP CARE

- Radiological studies and repeat laboratory studies are rarely necessary
- Restrict physical activity
- Period of restriction: CT grade + 2 weeks

CASE – LIVER LAC, NR

- 8 yo male; bike handlebars. Walked into house.
- Decreased LOC, taken to ED
- GCS 3, arrested – CPR x 3 minutes
- FAST positive - TO OR

CASE – LIVER LAC, NR

- Liver resection, cholecystectomy
- Blood loss> 3 liters
  - 3 U blood, 3 U FFP, 2 packs platelets, 100 ml cryo
- Abdomen closed post-op
- Transferred to CHP
CASE – LIVER LAC, NR

- Overnight, abdominal distension, anuric, abdominal compartment syndrome with splenic infarct and renal failure
- Back to OR; ex lap with decompression, removal of clots/fluid, placement of vac dressing and thoracostomy tube.

- Started on CVVHD.
- Tertiary exam: No other injuries
- Back to OR once more on day 3 for washout and closure of abdomen
- Coagulopathy treated and resolved
- Hemodialysis begun, extubated day 11
CASE – LIVER LAC, NR

ICU COURSE:
- Concern for mental status – EEG slowing - MRI normal
- Gram negative pneumonia
- Elevated bilirubin – shock liver
- Anemia – Epogen, Ferrlecit
- Seizure-like activity with hypertension:
  PRES syndrome (*Posterior reversible encephalopathy syndrome*)

CASE – LIVER LAC, NR

FLOOR:
- Antihypertensives, Keppra
- Off dialysis – BMP, cr, urine OP normal!
- Ongoing pulmonary issues: effusion with VATS, chest tube changes. Aggressive vibration, CPT, NS nebs, incentive spirometry
- Voice quality issues

CASE – LIVER LAC, NR

- Poor appetite – TPN, ND tube, Megace
- Angry outbursts, fear – Child Life, Behavioral Health. Vitamin B6 (Keppra ultimately switched to Trileptal)
- Pain – Pain Service
- Sleep issues – melatonin, relaxation
- Pen VK – splenic infarct
CASE – LIVER LAC, NR

- To Rehab day 43!
- Doing well, back in school!

RENAL INJURIES

Grade 1-2
Hematuria, non-expanding subcapsular hematomas, superficial cortical lacerations < 1 cm without affecting collecting system

Grade 3
Renal lacerations > 1 cm in depth; Collecting system not affected

Grade 4
Injury to renal artery/vein with contained hemorrhage; lacerations affect collecting system; expanding subcapsular hematoma that compresses the kidney

Grade 5
Shattered/devascularized kidney; ureteropelvic avulsions; complete laceration or thrombosis of the renal artery/vein
EARLY COMPLICATIONS

- Bleeding
- Urinary extravasation/urinoma
  - Almost 75% of children, even with severe grade IV laceration, have spontaneous resolution of urinoma
- Infection - related to devascularization
- Traumatic occlusion of main renal artery

LATE COMPLICATIONS

- Renin-mediated hypertension
- Loss of renal function – damage to parenchyma

TAKE-HOME POINTS

- Mechanism of Injury
  - MVC, falls and limited contact sports
- Non-Operative Management
  - Appropriate in majority of cases
- Operative Management
  - Usually declared within 12 hours
  - Most often a factor of number of other serious abdominal injuries, grade of injury, transfusion requirements
  - Stenting, hemorrhage control
- High Grade Renal Injuries from Minor Mechanisms
  - Bear investigation for underlying renal pathology

INJURIES TO STOMACH, SMALL BOWEL, AND COLON

- Crush injury – hollow viscus compressed violently against spine
- Burst injury – rapid compressive forces indirectly applied to a filled, distended hollow viscus (seat belt injuries)
- Shear injury – rapid acceleration/deceleration of organ that is tethered at one end (i.e., ileocecum)
INJURIES TO STOMACH, SMALL BOWEL, AND COLON

- All cause contamination of abdomen
- CT helpful, but diagnostic in only 60% of cases

Retroperitoneal air behind duodenum and left colon

Indications for Exploratory Laparotomy:

- Hemodynamic instability
- Pneumoperitoneum
- Peritonitis
- Bladder Rupture
- Abdominal tenderness with free fluid in pelvis on CT without solid organ injury

DUODENAL INJURY

- 2% to 5% of intra-abdominal injuries
- 50% due to child abuse
- 80% have additional injuries
- Perforation vs. hematoma
Duodenal Perforation:

- Mortality is directly related to time of diagnosis
  - < 24 hrs post injury → 11% mortality
  - > 24 hrs post injury → 40% mortality
- Delayed diagnosis occurs in 20-28% of cases

**Late Complication:** Stricture
CASE: BF

- 12 yo boy in MVC; diagnosed with grade IV splenic injury
- Hemodynamically stable; slow to show signs of gut motility
- Few days of increased bilirubin
- Tolerated clears (initially with pain), full liquids, early vomiting with regular diet
- Repeat CT, UGI normal (UGI to duodenum)

CASE: BF

- Felt to have duodenal hematoma; at last tolerated regular diet and sent home
- Back 3 days later, vomiting and dehydration
- Ex lap found massive strictures, adhesions covering small jejunal perf
- Resected; recovered well

Clinical Presentation:

- May be asymptomatic
- Abdominal pain in 80 to 100%
- Bilious vomiting (80%)
- Abdominal tenderness (70%)
- Peritonitis or pneumoperitonium
Duodenal Hematoma

- **Nonoperative Treatment**
  - NG decompression
  - TPN
  - Typically resolves within 2 weeks
  - If unresolved after 3 weeks, repeat CT or UGI

- **Operative Treatment**
  - If hematoma unresolved > 21 days, evacuation is the treatment of choice
  - May perforate if untreated

Mesenteric injury
“Seat Belt Syndrome”
- Caused by rapid deceleration, resulting in flexion of the upper body around lap belt and compression of the abdominal viscera
- Sudden increase in intraluminal pressure
- Results in injuries to the: 1) abdominal wall 2) intraabdominal contents and 3) lumbar vertebrae - Chance fracture

- For bowel injuries, clinical examination remains the critical diagnostic tool in an awake patient
- Only 60% of radiographic studies will be diagnostic
- Difficult diagnosis; delays occur in 10% of cases
**REVIEW**

- Which is the most sensitive tool for identifying bowel injuries?
- What is the concern with a mesenteric injury?
- What does pneumoperitoneum indicate?

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**PANCREATIC INJURY**

- 1% to 3% of abdominal trauma
- Vast majority are secondary to blunt trauma
- Mechanism: Commonly, bicycle handlebar injury
- Most patients present with epigastric pain

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**Diagnosis:**

- Laboratory studies: amylase / lipase
- Abdominal CT scan
  - Sensitivity - 72% (identifies 72% of true injuries)
  - Specificity - 99% (identifies 99% of true negatives)
- Diagnostic Categories:
  - Pancreatic contusion
  - Pancreatic transection
Amylase > 200 and Lipase >1800 correlated with pancreatic transection or major pancreatic ductal injury requiring operative intervention

- LOS for contusion: 6 days
- LOS for transection: 11.5 days

-Nadler EP et al. J. Trauma 47: 1098, 1999

Nonoperative Treatment:
- Reserved for contusions or minor ductal injury
  - NG decompression
  - TPN

Operative Treatment:
Pancreatic Transection or major ductal injury:
- Distal pancreatectomy for the body or tail
- Pancreatic enteric anastomosis for the head
Complications:

- **Post-traumatic pancreatitis**
  - Pancreatitis can be a complication of ANY abdominal injury; develops 3-4 weeks after trauma
  - Symptoms: persistent abdominal pain, vomiting, early satiety, persistently elevated amylase/lipase
  - Usually related to major duct disruption

**CASE: MR**

- 6 year old girl presented with abdominal pain, vomiting after bike handlebar injury
- CT, MRCP shows pancreatic injury; amylase/lipase 1870/1450
- Pain, A/L decreased on NPO/TPN
- Day 9: increased distension, A/L
CASE: MR

- TPN
- NJ feeds not tolerated
- Octreotide started; stopped secondary to nausea/vomiting
- NJ feeds tolerated at 3 weeks
- Fever; negative cultures
- Family unwilling to go home on TPN

- At 6 weeks, pancreatic cystogastrostomy
- Progressed easily to regular diet; discharged home
- Ultrasound 1 month later shows no evidence of pseudocyst
MANAGEMENT OF PANCREATIC PSEUDOCYST

- Controversy – operative vs nonoperative
- May resolve on its own
- Watchful waiting; nutrition support
- Monitoring with ultrasound vs CT
- ERCP with duct stenting

REVIEW

- What two areas of the body should be carefully examined when a seat belt sign is noted?
- Why is NPO status and an NG tube important as part of the treatment for a pancreatic injury?

SUMMARY:

- Diagnosis of seat belt injuries requires a high index of suspicion
- Non-operative treatment is standard in hemodynamically stable children with blunt spleen and liver injuries
- Operative treatment often required for small bowel injuries, pancreatic transection or ductal disruption, and duodenal injuries