Case 1

- 8 y/o male
- Auto vs Bicycle
- No helmet
- LOC 2-3 min
- Combative

- HR 127, 141/77, 22, 99%
- Shock index = 0.9*
- Slight facial abrasions
- Right wrist deformity
- FAST negative

*Age-adjusted shock index 4-6 yrs >1.22; 7-12 y/o >1.0; 13 and older >0.9

Case 1

- CT Head and is negative
- 6 hours post-injury (just prior to wrist reduction), patient complains of abdominal pain
- Back to CT for Abdomen and pelvis with IV contrast

Grade 4 Splenic Injury

CT

- Grade 4 injury
- 40% devascularized
- Large hemoperitoneum
- Initial Hb 13
- 4 hours post-injury
- HR 88; 148/77
Nonoperative management

- No further bleeding
- No symptoms
- Home in 48 hours

Do we need to re-image this patient?

- History
  - Prior to 1999
    - Routine reimaging
    - “Evaluate for complications”
    - “Document healing”

1992

- “This management approach [nonoperative management], based on the use of either serial computed tomography scans, liver/spleen scans, or ultrasonography to diagnose the injury and document resolution, achieves results that exceed those of operative management for all injuries.

Should we re-image the splenic injury

- What might we be looking for?
- Pseudoaneurysm
- Splenic cyst
- Continued bleeding?
- “Signs of healing”

Splenic artery pseudoaneurysms

- Pseudoaneurysms
  - ‘false aneurysms’
  - breach in the vessel wall
  - bleeding is contained by the adventitia or surrounding perivascular soft tissue
Splenic artery pseudoaneurysms

- Pseudoaneurysms
  - direct communication of blood flow between the vessel lumen and the aneurysm lumen

- Splenic artery pseudoaneurysms

  - Pseudoaneurysms
    - risk of rupture
      - pseudoaneurysm > true aneurysm (of comparable size)
    - poor support of the aneurysm wall

Knowledge of pseudoaneurysms: Pancreatitis

- Weakening of the wall by pancreatic enzymes.
- Enzymes → necrotizing arteritis with destruction of vessel wall architecture
- Pancreatic pseudocyst
  - Vascular erosion from enzymes within the pseudocyst
  - Direct compression
  - Ischemia
Traumatic Pseudoaneurysms

- Often found **WITHIN** the spleen
- Surrounded by splenic parenchyma

What is the significance

- Post-traumatic splenic Pseudoaneurysm?

Safavi et al (2011)

- 186 splenic injuries
- 10 (5.4%) developed pseudoaneurysms
- Associated with grade III (3/39 [8%]) and grade IV (7/41 [17%]) injuries


Safavi et al (2011)

- 7 spontaneous thrombosed of pseudoaneurysm
- 2 Angiographic embolization
- 1 emergency splenectomy for delayed hemorrhage

The significance of pseudoaneurysms

- 16 articles
  - 1 prospective study
  - 4 retrospective reviews
  - 11 case reports were reviewed
  - 45 Splenic artery pseudoaneurysms were reported.

The significance of pseudoaneurysms

There is no evidence to support or dispute the routine use of follow-up imaging and embolization of posttraumatic SAP in the pediatric population.

At present, the decision to treat SAP in stable children is at the discretion of the treating physician. A prospective study is needed to clarify this issue.

What’s the incidence of delayed splenic bleeding?

Retrospective Study

- 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.

Reported incidence delayed splenic bleed

- We don’t know if he had a pseudoaneurysm
- We don’t know if imaging would have prevented the death
- 1 of 606 (0.16%) children with blunt splenic injury
- Abstract at WPTC
ATOMAC re-imaging
• 5 centers – 267 spleen injuries
• No routine re-imaging
• 152 patients isolated splenic injuries and follow up

ATOMAC
• Median age 12.7 years [IQR: 8.8, 14.6].
• Median splenic injury grade was 3 [IQR: 2, 4].
• 10 patients (6.6%) re-imaging related to abdominal injuries
• 2 (1.3%) patients were readmitted

ATOMAC
• 7 ultrasound
• 3 CT
• 0 with MR
• 0 with angiography

ATOMAC
• Follow-up re-imaging identified
  – No (0%) splenic artery pseudoaneurysms
  – 3 splenic cysts (1.9%)
Splenic Cysts

- Management
  - Typically based on size
  - Size < 5cm → No treatment
  - Size > 5 cm → Treat if symptomatic
  - Strongly correlated with size

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Non-selective reimaging spleen

- Few studies
  - “known unknown”
- Very few re-admissions
- Symptomatic patients

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Durkin et al. 2016

- A retrospective review
- 12 year (2002-2014)
- Contrast Enhanced US (CEUS) all patients
- 5 to 10 days postinjury
- FDA-approved ultrasound contrast agent
- CT with IV contrast also done – all patients
**RESULTS:**
- 35 spleen injuries [grade 3 (1-5)]
- 8 combined liver/spleen
- Median Injury Severity Score (ISS) was 13 (2-72)
- 72% blunt and 28% penetrating

**Splenic pseudoaneurysm**
- 3 children (9%) developed splenic pseudoaneurysms
- All were identified on day 5 of admission.
- The median injury grade was 3 (2-4)
- All asymptomatic
- None embolized
- All resolved with thrombosis
- Median time to resolution was 8 days (7-40)

**Splenic Pseudoaneurysm**
- No association between size and symptoms
- No association between grade of injury and presence of pseudoaneurysm
<table>
<thead>
<tr>
<th>What we learn…</th>
<th>Should we document healing?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Splenic pseudoaneurysms are quite common</td>
<td>Decision to return to sports</td>
</tr>
<tr>
<td>Most are small</td>
<td>– APSA guideline</td>
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<tr>
<td>Imaging leads to more imaging</td>
<td>‘Family comfort’</td>
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<tr>
<td>Study also confirms → resolution</td>
<td>‘Physician comfort’</td>
</tr>
</tbody>
</table>

**APSA Guideline**

- No ROUTINE reimagng required
- Selective use
- Healing – predictable time-course
- Expert opinion: Grade + 2 (in weeks)
- Followed > 15 years

**GRADE assessment (2015)**

- Routine imaging lead to interventions that may or may not have benefited patients. A possible role for selected liver reimaging was suggested by some adverse outcomes in one small retrospective series
- Recommendation: (2C*) Routine reimaging in children with spleen injury is not indicated …


What about liver injuries?
Liver Injury Complications
• Pseudoaneurysm
• Hemobilia
• Biloma

More case reports
• “14-year-old boy with a blunt hepatic trauma grade III, who showed a pseudoaneurysm with active bleeding into the abdominal cavity after mobilisation on day 9.”

Safavi et al
• 176 liver injuries
• 3 (1.7%) developed pseudoaneurysms.
• All 3 were associated with grade IV injuries (3/11 [27%]).

Safavi et al
• 1 child underwent early embolization
• 2 developed delayed hemorrhage requiring emergent treatment
Safavi et al - Conclusions

- Pseudoaneurysm development after blunt abdominal trauma is associated with high-grade splenic and liver injuries.
- “Routine screening” …warranted because of the “potential risk of life-threatening hemorrhage”

Durkin et al.

- 57 Liver injuries, + 8 liver/spleen
- 65 Total cases

Durkin

- Hepatic pseudoaneurysm 14/57 (25% of all those with hepatic injury).
- Predominantly grades III (40%) and IV (33%)
- 6/14 (43%) children became symptomatic
  - worsening abdominal pain
  - hemodynamic instability
  - acute drop in hemoglobin
- 5/6 symptomatic children embolised
  - median of 7 days postinjury (3–11) days postinjury
  - 1 was monitored and subsequently resolved
- Natural history ?

Biloma

- Collection of bile within or around the liver
- Typically associated with ductal injury

Biloma

- Collection of bile within or around the liver
- Typically associated with ductal injury
Hemobilia
• GI bleeding after liver injury
  – Uncommon
  – Arterial bleeding into biliary system
  – Symptoms consistent with UGI
    • Melana
    • Bloody emesis
    • Signs of hypovolemia
• Unlikely to be asymptomatic

Liver Injury
• No pseudoaneurysms were found in grade 1 or 2 injuries
• Some liver pseudoaneurysms bleed
• Some patients might benefit from re-imaging on an individual basis
• Group – undefined; probably high grade injuries

Liver
• Biloma
• Hemobilia
• Patients are symptomatic
  – Selective imaging for symptoms

Do renal injuries require reimaging?
Renal re-imaging

• Fewer renal injuries vs liver/spleen
• Historically
  – Serial re-imaging
• More involvement by urologists

Follow up Renal Ultrasound

• No great studies in children
• 50 patients
  – 28 CEUS patients were retrospectively compared with
  – 22 CT follow up patients.
• No patients had any evidence of long-term complications in either cohort.

Follow up Renal Ultrasound

• The lack of benefit of usage of renal ultrasound demonstrated in the acute post-injury surveillance period calls into question any benefit immediately following the blunt trauma

Studies of renal function

• DMSA Scanning
• Technetium-99m-dimercaptosuccinic acid
• Short-lived radioisotope
• IV ➔ Directly to the kidneys
• Stays radioactive for a few hours up to a day.
• Measures renal function

Studies of renal function

• 17 children (mean age, 10.4 years)
• Complete healing was documented in all cases
• Occurred w/i 3 mo of injury
• Renal scarring and volume loss were evident for all grades IV and V injuries
Studies of renal function

- Decline in percentage of total renal function corresponding to injury severity
  - Normal = 50%
  - Grade II and III = 44.7 +/- 8.4% function
  - Grade IV = 41.8 +/- 9.2%
  - Grade V = 29.5 +/- 7.9%


Severe collecting system injury

- Patients with UPJ disruption
- Can be salvaged by initial drainage of the urinoma followed by deferred correction


What have we learned?

- Spleen pseudoaneurysms are common and often small
- Most resolve without treatment
- Splenic cysts are rare, but only need treatment if symptomatic
- Delayed bleeding is rare, and we do not have a direct correlation with abnormal imaging and re-bleeding

What have we learned?

- Liver pseudoaneurysms are less common
- Only high grade liver injuries develop pseudoaneurysms
- Liver pseudoaneurysms may bleed, sometimes catastrophically
- Other complications needing intervention are usually clinically apparent
What have we learned?

- Renal injuries: Get imaged often, and in multiple ways, but these do not change care in most cases
- Grade V renal injuries and those with collecting system injury may benefit.

Thank you