**Image Gently/Image Wisely and the Analysis of the Pediatric Lumenal GI Tract**

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**Objective – To Discuss**

- Radiation safe imaging workups and Ultrasound’s role in diagnosis for 2 common complaints possibly involving the pediatric lumenal GI tract and their simulators. They are:
  - vomiting neonate
  - child/adolescent with RLQ/pelvic pain

**Radiation Exposure – The Problems**

- Deterministic (threshold for injury) vs Stochastic (no absolute safe lower threshold) Radiation Effects
  - Dangerous for the very young
  - Must decrease unnecessary exams
  - Be concerned re: cumulative doses
  - Potential help: tailored exams
  - Use alternative methods, when possible

**Effective Responses/Campaigns from the Radiology (US) Community**

- Image Gently followed by Image Wisely with US’ Ultrasound First and Image Soundly
- The Image Gently site shows work by panels on ways to reduce radiation exposure in many areas of pediatric diagnosis eg fluoroscopy, nuclear medicine (Slovis Med School course)
- The Ultrasound community has reinforced methodologies to evaluate patients by low radiation cost exams (i.e. US), when able, First

**Radiation Concerns Have Increased Over the Last Decade**

- “Consensus statements on radiation risk suggest that it is reasonable to act on the assumption that low-level radiation may have a small risk of causing cancer.
- The medical community should seek ways to decrease radiation exposure by using radiation doses as low as reasonably achievable and by performing these studies only when necessary.”


**Ultrasound is an Ideal Tool**

- Highlighted as: Safe, Effective, Affordable
- Where it can triage.. it should
- Where it can make final diagnosis.. it should
Ordered for abdominal distention, hepatomegaly, dropping HCT—possible liver injury s/p forceps delivery

Echogenic material was seen in dilated small bowel

Here’s Another Image

What do you see?

Blind Ending Loop of Small bowel With an Arrowhead Configuration

Midgut Volvulus

We reviewed use of fluid (water) as a contrast agent

Images were similar to obtained by CT using (iodinated) contrast

only.. the contrast agent is “echoless”

Water -- a friend of US

Newborn with Bilious Vomiting

- Usually due to Sepsis or Obstruction
  - This is a radiologic emergency since midgut volvulus may result in distal bowel ischemia or necrosis.
- This is despite only 20% having midgut volvulus (69% benign, idiopathic cause and 10% having a lower colon cause)
Relationship of SMA to SMV: a possible clue to bowel malrotation

- >200 children with nonbilious vomiting
  - 5 of 5 with SMV to left of SMA
  - 1 of 4 with SMV anterior to SMA had bowel malrotation

Weinberger et al AJR 1992; 159: 825

US in the Workup for GER

- Shows more reflux episodes than UGI
- Riccabona [Eur J Ped 151:655, 1992] 100% sensitive, 87.5% specific
- Cohen [Radiology 164,805; 1987] 48 true (+), 6 true (-), 1 false (-)

US to diagnose GER

- Longitudinal
- Transverse plane
- Air bubbles in fluid echoes, seen in esophagus & stomach
- E = esophagus
- S = stomach

One of the benefits of US for all Lumenal GI tract US

- Can examine the patient w/ hand or transducer
- Can wade through/verify correct and incorrect or limited physical exam information
- Can evaluate what is happening in real time e.g. moving vs nonmoving vs hyperperistalsing bowel

New Onset Projectile Vomiting at 6 weeks – Differential Dx

- Viral gastroenteritis
- GER
- Pylorospasm
- Hypertrophic Pyloric Stenosis
HPS – can be diagnosed on UGI

Caterpillar sign
Peristalsis against obstruction

Mass impression on antrum ("shoulder" sx)
Proximal pylorus filled ("beak" sign)

Elongated Pylorus ("string" sign)

UGI "Double Track" Sign

Haran et al 1966

US Bagel or Doughnut Sign of HPS

7 week old
First born male

Projectile vomiting
Since week 4

7 = 5.3mm
2 = 4.1mm
3 = 4.4mm
4 = 4.3mm

HPS – higher frequency linear array transducer

Ancillary US Signs - HPS

- Double Track Sign
  - Echogenic parallel lines denoting the mucosal complex of the pylorus

- Shoulder sign
  - Hypertrophic muscle impression on gastric wall

- Mucosal Nipple (Antral heaping) Sign
  - Antral protrusion - redundant pyloric mucosa

HPS: + Measurements

- Wilson and Vanhoutte [JCU 12:201, 1984]
  - 2cm pyloric length is definitively abnormal in 33 of 33 cases

- Stunden et al [Pediatr Radiol 16:200, 1986]
  - All positive cases 18mm or longer
  - All negative cases 14mm or less

- Width of muscle: 4mm → 3mm
Pylorospasm’s US findings can simulate those of HPS

- Elongated length of pylorus
- Thickened pylorus muscle
- Double track sign

Main difference:
- HPS findings are essentially unchangeable
- Pylorospasm findings change during study

Images of case of Pylorospasm

Changeable images of pylorus

US of Pylorospasm

- Watch how the pylorus handles a fluid load!!
- Are wall thickness or length measurements ever normal?
- Is the antropyloric region changeable??

Patience is a Virtue

Pyloric Length Measurements in PS can simulate those of HPS

<table>
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<th>mm</th>
<th>30</th>
<th>27</th>
<th>24</th>
<th>21</th>
<th>18</th>
<th>15</th>
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- 20mm length
- Black arrow = 18mm
- = 14mm length

The Diagnosis of Appendicitis

- At times clinically confusing (see Cope’s “The Acute Abdomen”)
- Classic: McBurney point to RLQ
- May not be febrile
- May have different pain complaints related to different positions eg RUQ, pelvis, retrocecal

I. Some Personal History on the Diagnosis of Appendicitis by US

- Pylaert’s mid to late 1980’s work using high frequency linear array transducers and compression to diagnose AP was a game changer. It allowed us to diagnose nonperforated Appendicitis by US (color flow in inflamed wall can help as well)
- Until then, we helped only when we could
  - see a collection in the pelvis from perf or
  - diagnose a gynecologic simulator of AP
RLQ/Pelvic Pain in the Child/Teen: Non-Gyn (GI/GU) Considerations

- Appendicitis
- Crohn’s disease
- Mesenteric adenitis
- Ureteral stone
- Bladder infection

All these entities may be diagnosed by US

Pelvic Pain in the Pediatric Patient has Gynecologic Considerations

- Hemorrhagic Cyst
- Uterine Obstruction
- Ovarian Torsion
- Teratomas (& other Ovarian Masses)
- Pelvic Inflammatory Disease
- Ectopic Pregnancy (will not be discussed)

16yo with Right pelvic pain 21,000 WBCs

We often ask for a Pelvic US and a RLQ (empty bladder) US

The pelvic US was normal

We obtained a RLQ US

Diagnosis ?

Appendicitis

Wide (>6mm) tubular Noncompressible blind ending structure with a contained appendicolith

Linear transducer RLQ

Nonperforative Appendicitis

16yo with Right pelvic pain 21,000 WBCs

Nonperforative Appendicitis

normal appendix

15 year old with right pelvic pain

What do you See?

Diagnosis ?

Crohn’s Disease

Regarding Gyn Simulators

As with all “Pediatric” Imaging:
Normal US findings change over time

- Changes are affected by
- The Child’s Age … as well as
- her Changing hormonal environ

One must be aware of normal and expected findings for the various ages of “childhood”
13 yo Girl
Acute
Pelvic Pain

Hemorrhagic Ovarian Cyst

- Not an uncommon cause of lower abdominal or pelvic pain in the adolescent
- Often a teen’s 1st complaint of pelvic pain
- Important simulator of other abnormalities
- Image may be simulated by TOA
- Image may be simulated by Endometrioma

Any Thoughts?

Some Surrounding Free Fluid

Ovarian Torsion — Early Diagnosis is a Goal

- Rare before menarche
- Common in immediate postmenarchal years
- Results from Partial or complete rotation of the ovary on its pedicle → lymphatic, then venous, then arterial compromise

- More common (?) with mass in ovary
- Fever is rare.
- c/o Sudden localized sharp pain (unlike AP).

US of Ovarian Torsion

- Variable images (each with its own differential) are related to degree of internal hemorrhage as well as stromal edema
  - Cystic
  - Cystic with septations
  - Complex (solid and cystic)
  - Solid (often homogeneous)

Ovarian Torsion

* = cul de sac fluid

Another Patient

13yo with sudden Pain Hours ago

17yo with acute pain an enlarged 58cc right ovary with a cyst

17yo with acute pain an enlarged 58cc right ovary with a cyst

Peripheral flow

For comparison

Peripheral flow

It was tipped
Hematometrocolpos

Scattered debris is seen in a dilated vagina and uterus.

PID – an epidemic among teens

All 3 of these criteria must be present

- Lower abdominal pain history or Lower abdominal tenderness (w/ or w/o rebound)
- Cervical Motion Tenderness
- Adnexal Tenderness

Pelvic Inflammatory Disease - PID

- US findings by stage:
  - 1 Salpingitis – No abnormal US findings
  - 2 Salpingoophoritis – enlarged adherent adnexa (Koala Bear sign)
  - 3 TOA – mixed mass replacing ovarian tissue. Can contain cystic tubular hydrosalpinx

Teenager with Pelvic Pain

US should examine (to evaluate for):

- Ovary for enlargement (in cases suggesting torsion or possible PID)
- Uterus for possible obstruction (in cases of primary amenorrhea)
- Nearby bowel for possible AP or Crohn’s
- [Pelvis for possible ectopic pregnancy (in cases of secondary amenorrhea)]

Summary

- Adhering to the Alara principle is necessary in pediatric workups
- US is a key tool in keeping workup radiation doses down
- Examples have been shown of its aid in assessing to pediatric lumenal gastrointestinal tract. It helps elsewhere.
- Use the transducer ... “It works if you work it and don’t give up no matter what”