Scanning the Appendix: A Step-by-Step Approach

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Objectives

Identify	Explain	Describe
Identify the sonographic appearance and anatomical variations of the appendix to support accurate localization during examination.	Explain the benefits and limitations of sonography in appendiceal evaluation to support appropriate clinical application.	Describe a systematic scanning protocol and recognize secondary signs of inflammation to improve diagnostic confidence in clinical practice.

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Pathophysiology of appendicitis

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Progression of Appendicitis[1]

- Blind-ending tube with a narrow lumen
- It contains feces and is easily obstructed

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Progression of Appendicitis[1]

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Ultrasound and the Appendix

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Ultrasound evaluation of the appendix

- Appendicitis is the most common surgical condition in children
  - The annual incidence in the United States is estimated at 83 cases per 100,000 population[2]
  - The peak incidence is between 15 and 19 years and is slightly more common in males than females, with a male-to-female ratio of approximately 1.4:1[2]
  - Children have a higher risk of perforation compared to adults, with perforation occurring in approximately 30% of pediatric hospital admissions for appendicitis
    - May be due to delays in diagnosis and treatment due to nonspecific presentations that could mimic other gastrointestinal illnesses[2]
- Increasing trend in using ultrasound to evaluate the appendix
- Identifying the appendix using ultrasound is a challenge
  - Due to appendiceal location
  - Due to technical expertise of the sonographer and radiologist
  - Wide range of identification rates performed in the literature

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Identification Rates for Visualizing the Appendix with Ultrasound

One study by Trout et al. had the following numbers for identifying the appendix[3]

- Exams performed by sonographers with some radiologist oversight
  - The appendix was seen in 24.4% of patients
  - 66.5% sensitivity
  - 95.9% specificity
  - 75.7% positive predictive value
  - 93.6% negative predictive value
- Pediatric-trained sonographers identified the appendix at a rate of 38.7% vs. 19.3% among general sonographers
- Within the group of patients where the appendix was not seen (75.6% of the total patient population), 7.1% had appendicitis[3]

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Let's Compare Ultrasound to Computed Tomography (CT)

In another study, analyzing ultrasound and CT for pediatric appendicitis, sensitivities varied between the modalities[4]

- CT
  - Sensitivity of 95%
  - Specificity of 93%
  - Accuracy of 94% for appendicitis
- Ultrasound
  - Sensitivity of 78%
  - Specificity of 93%
  - Accuracy of 89%
- To note, when the patient population was further divided, the significant difference in sensitivities were in the older age group
  - The sensitivity between the 2 modalities was similar in patients < 10 years old[5]

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Why is the appendix so hard to visualize?

Appendix position is variable[6]

- Post-ileal
  - Posterior to the ilieum
- Pre-ileal
  - Anterior to the ileum
- Pelvic
- Sub-cecal
  - Deep to the cecum
- Retrocecal
  - Posterior to the cecum
  - One of the most common locations
- Ectopic
  - The appendix is not in any of the above locations

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Why is the appendix so hard to visualize?

Retrocecal – Most common location[6]

- Behind the cecum
- Making it very difficult to see the appendix sonographically due to air/gas
- Appendix may be seen by looking more in the right paracolic gutter or by rolling the patient in the decubitus position and scanning more from the patient's back
- Manual pressure may also help by pushing air/gas out of the way to visualize the appendix

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Why is the appendix so hard to visualize?

- Other reasons[7]
  - Operator experience
  - Patient obesity
  - Tip appendicitis
    - The early start of appendicitis where the tip is enlarged
  - Perforation
  - Lymphoid hyperplasia

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Why use ultrasound to visualize the appendix? [7]

- Does not use radiation
  - Pediatric population
  - Pregnant patients
- Less expensive
- Can be used portably
- Ability to see structures moving in real-time
- Can position the patient differently to possibly see the appendix
- Ability to apply pressure on the appendix to appreciate if it compresses
- Assess a positive McBurney's point sign

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What are you looking for when trying to see the appendix? [8]

- A blind-ending, tubular structure that is aperistaltic
- Should also attempt to see the appendix connecting into the cecum
- Can try to identify the terminal ileum to attempt to locate the appendix
  - The appendix is approximately 1 cm inferior to the terminal ileum
  - Remember that not all appendices will be in the same area
- It is important to confirm that the structure is blind-ending, as to not confuse the appendix for a loop of bowel

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So you found it… How do you know if it is normal or inflamed?

Normal

- Measure the outer wall to outer wall of the tip of the appendix
- Normal will measure <6mm
- Not hyperemeic
- No adjacent hyperechoic mesenteric fat
- The appendiceal layers are visualized inside the appendix
- Air is visualized in the appendix
- Appendix is compressible
- Adjacent bowel exhibits normal peristalsis

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So you found it… How do you know if it is normal or inflamed?

Abnormal

- Measure the outer wall to outer wall of the tip of the appendix
- Abnormal will measure >6mm
- Can exhibit hyperemia in the walls
- Adjacent hyperechoic mesenteric fat
- Fluid is visualized in the appendix
- Appendix is non-compressible
- Appendicolith may be seen

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Lymphoid Hyperplasia[9]

- The lamina propria is the layer of connective tissue within the digestive tract
- The appendiceal lamina propria normally contains lymphoid follicles
  - Especially in the pediatric population
- These lymphoid follicles may hypertrophy in response to gastrointestinal inflammatory diseases, such as viral gastroenteritis and mesenteric adenitis
- Causes thickening of the lamina propria within the appendiceal wall making the appendix appear more prominent (Xu et al. 2016)
- Importance of looking for secondary signs of inflammation and seeing if the appendix compresses

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Importance of Finding Secondary Signs of Inflammation[10]

- What does that mean?
- Assessing for surrounding structures that might appear inflamed, with or without the presence of the appendix
- Includes:
  - Hyperechoic mesenteric fat
  - Enlarged mesenteric lymph nodes
  - Free fluid

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Importance of Finding Secondary Signs of Inflammation

- A few points to remember regarding secondary signs
  - Some studies have found that the absence of secondary signs with or without direct visualization of the normal appendix can exclude the diagnosis of acute appendicitis[10]
  - The rate of appendicitis has been reported to be as low as 5.8% to 7.1%, in cases where ultrasound does not identify the appendix or any secondary signs of inflammation[11]
    - Other studies have found there is a false negative rate with using ultrasound and secondary findings
    - The ordering clinician should assess the patient's clinical findings and determine if further imaging is necessary
  - Secondary signs are also helpful when the appendix appears equivocal in regard to appendicitis
    - Size is at the upper limits and/or it may slightly compress
    - Lack of additional secondary findings of inflammation, especially hyperechoic mesenteric fat, should make one question whether the patient truly has appendicitis[4]

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Equivocal Appendix

- 9-year old female
- RLQ and pelvic pain
- Elevated WBC and debris in the bladder along with visualization of the appendix
  - Measuring at the upper limits of normal
  - Appendix did not fully compress
  - Hyperechoic fat was present
  - Appendix area appeared hyperemeic
- Urinalysis showed possible UTI
- Patient was treated with antibiotics, not surgically

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Importance of Determining if Appendicitis looks Complicated vs. Uncomplicated[8,12]

- May change the course of treatment
  - Surgery vs. antibiotic treatment
- Evaluate for an appendicolith
- Evaluate for obvious signs of perforation
- Just because an appendix doesn't appear complicated, doesn't mean it isn't
- The ordering clinician may also use the white blood cell count value in determining if the patient is a candidate for antibiotic treatment
  - If it is under a certain number

Two years later…

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What can make it easier to see the appendix?

Good question with not really an answer

- Depends on the patient's anatomy, bowel, and appendix positions

What can help?

- A succinct protocol
- Assessing the abdomen and pelvis thoroughly can assist with seeing the appendix and possibly seeing secondary signs of inflammation

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Appendix Protocol

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Knowing the patient's clinical history[7]

- How long has the patient's pain been present?
  - If it has been there for awhile (meaning several days), odds are it probably won't be appendicitis
  - Acute onset of pain is typically associated with appendicitis
- Pain was present, but has now gone away
  - Could be due to a viral issue or could indicate that the appendix has ruptured
  - Pain goes away after appendiceal rupture, but this is a surgical emergency
- Is there an elevated white blood cell count (WBC)?
  - May be the result of appendicitis
  - Caveat – sometimes appendicitis can be present with a normal WBC
- Has the patient had a urinalysis performed?
  - To assess for a urinary tract infection or hematuria (stone)
- Has the patient had a urine pregnancy test performed?
  - To assess for a possible ruptured ectopic if excessive free fluid is appreciated

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Where to scan?

- In order to assess for appendicitis or other signs of inflammation, the abdomen and pelvic areas can be evaluated in a U-shape pattern
- A high-frequency linear transducer should be utilized
  - Start with the highest frequency transducer possible
  - Change based on penetration needs

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Step 1: Start in the Right Lower Quadrant (RLQ)

- View the common iliac artery and vein
  - The appendix may be seen anterior to these structures
  - Can appreciate if free fluid is present
    - Although small amounts may be physiologic
  - Can appreciate if lymph nodes are present
- Obtain still images in longitudinal and transverse planes
- Obtain a cine clip of the RLQ in transverse and longitudinal planes

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Step 2: Move to the Right Paracolic Gutter

- May want to change the view from traditional linear to convex
  - Obtain a wider field of view
- The appendix may be seen in this location if not appreciated in the RLQ
  - Can appreciate if free fluid is present
    - Although small amounts may be physiologic
  - Can appreciate if lymph nodes are present
- Obtain still images in longitudinal and transverse planes
- Obtain a cine clip of the right paracolic gutter in transverse and longitudinal planes

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Step 3: Move to the Right Upper Quadrant (RUQ)

- May want to change the view from traditional linear to convex
  - Obtain a wider field of view
- Mainly assessing for free fluid in Morison's Pouch
- May find the appendix in this location (rarely)
- Obtain still images in longitudinal and transverse planes
- Obtain a cine clip of the RUQ through the RLQ

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Step 4: Move to the Pelvis

- May want to change the view from traditional linear to convex
  - Obtain a wider field of view
- Mainly assessing for free fluid in the pelvis
- Obtain still images in longitudinal and transverse planes
- Obtain a cine clip of the pelvis in transverse and longitudinal planes if necessary

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Step 5: Move to the Left Lower Quadrant (LLQ)

- May want to change the view from traditional linear to convex
  - Obtain a wider field of view
- Mainly assessing for free fluid in LLQ
- Obtain still images in longitudinal and transverse planes
- May obtain a cine clip if necessary

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Step 6: Move to the Left Upper Quadrant (LUQ)

- May want to change the view from traditional linear to convex
  - Obtain a wider field of view
- Mainly assessing for free fluid in LUQ
- Obtain still images in longitudinal and transverse planes
- Obtain a cine clip of the LUQ through the LLQ

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Step 7: View the Right Lower Quadrant (RLQ) in the Left Lateral Decubitus (LLD) Position

- Changing the patient to the LLD position may assist with moving air in the bowel
  - Patient's left side is down
- May allow the appendix to be visualized
- If the appendix was visualized in the supine position, the LLD position may improve visualization
- View the common iliac artery and vein
  - The appendix may be seen anterior to these structures
  - Can appreciate if free fluid is present
    - Although small amounts may be physiologic
- Obtain still images in longitudinal and transverse planes
- Obtain a cine clip of the RLQ in transverse and longitudinal planes
- If the patient has a full bladder, try having the patient void
  - May assist with visualizing the appendix

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Appendicitis with a Normal WBC

- 25-year old female with a history of RLQ and periumbilical pain
- WBC was normal

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Perforated Appendicitis

- 6-year old male presenting with pain about a week prior
  - Pain had subsided, but fever was present
- Elevated WBC

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Importance of Other Findings

- In looking extensively at the abdomen and pelvis, one may find a different cause for the patient's pain[7]
- Examples include:
  - Intussusception
  - Renal stone (either in the uteropelvic and/or uterovesical junctions)
  - Ruptured ovarian cyst
  - Ruptured ectopic pregnancy
  - Adnexal pathologies
  - Adjacent inflamed bowel

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Appendix Case Review

Is it Normal or Abnormal??

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Case 1

- A 10-year old male presents with RLQ pain and vomiting
- WBC is normal
- Afebrile

Normal appendix with lymphoid hyperplasia

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Case 2

- 12-year old female with RLQ pain
- Elevated WBC
- Fever
- Nausea/vomiting

Appendicitis with appendicolith, hyperechoic mesenteric fat, hyperemia, and non-compressible appendix

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Case 3

- 20-year old female
- RLQ pain
- Afebrile
- Elevated WBC
- Transvaginal ultrasound was ordered to evaluate for ovarian torsion

Appendicitis incidentally seen on Transvaginal ultrasound

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Case 4

- 5-year old male with periumbilical pain
- Afebrile
- Nausea/vomiting
- Normal WBC

Normal appendix

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Case 5

- 25-year old female
- RLQ pain
- Nausea
- Elevated WBC
- Febrile
- Positive pregnancy test

Appendicitis with at least two appendicoliths appreciated

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In Summary

- The appendix can be a very difficult structure to consistently identify using ultrasound
- With a succinct, yet thorough, protocol one should be able to either see the appendix and/or visualize secondary signs of inflammation
- Know that even with consistent practice and experience scanning the appendix it can be difficult to appreciate it, and at times appendicitis may be missed with ultrasound
  - That is why a thorough clinical exam along with medical imaging is key when assessing for this pathology.

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