Clinical Pathway:
Clinical and Diagnostic Evaluation for Acute Appendicitis
Phoenix Children's Hospital

Disclaimer

This clinical pathway is not intended to replace clinical judgment. It is meant to assist licensed independent practitioners and other health care providers in clinical decision making by describing a range of generally acceptable approaches to the diagnosis and management of a particular condition. A particular patient's circumstances should always be considered when a practitioner is deciding on a course of management.

Scope

General

- This clinical pathway is designed to help standardize the approach to the history, physical exam, and diagnostic testing to help accurately lead to a diagnosis or exclusion of the diagnosis of Acute Appendicitis (AA). This pathway addresses how to handle some diagnostic dilemmas especially equivocal results on diagnostic imaging.
- This pathway does not address the management of AA after the diagnosis is confirmed. Surgical strategies, complications, and post-operative management are not described here and likely belong in a separate pathway with a surgical audience.

Inclusion Criteria

- Population: Patients 3-18 years old presenting to the Phoenix Children's Hospital Emergency Department (ED) with lower or diffuse abdominal pain concerning for acute appendicitis

Exclusion Criteria

- Children < 3, toxic appearance, hemodynamic instability, previous appendectomy, pregnancy, history of inflammatory bowel disease, trauma patients, CT done by outside institution prior to transfer, ongoing treatment for malignancy, history of organ transplant, or patients with severe developmental delays.
- It is important to recognize that **acute appendicitis can occur in ANY of the above excluded patient populations**. However, these patients will likely require different considerations in their evaluation that prevent these general recommendations from being applied to them.

Background

- Acute appendicitis (AA) is the most common surgical emergency in pediatrics with 70,000 pediatric appendectomies performed annually in the United States. The diagnosis of AA can be challenging with well-recognized inconsistencies in history, exam, and laboratory evaluation. There remains a high rate of negative appendectomies and perforations indicating refinement in diagnostic evaluation is needed.

- Clinical prediction rules to determine the likelihood of AA have been thoroughly researched and found to be helpful in contributing to decision-making,but lack the sensitivity and specificity to be definitive screening tools.
- Historically, computerized tomography (CT) has been relied on to make the diagnosis of AA given the above inconsistencies. However, in recent years most pediatric centers have moved towards ultrasound (US) as their first-line imaging modality in an effort to reduce exposure to ionizing radiation which has been linked to an increased risk of long-term malignancy.
- US has been shown to accurately confirm or exclude appendicitis when the appendix is clearly identified. Unfortunately, the rate of equivocal (non-diagnostic) US remains high with some centers reporting rates as high as 50%.
- How to proceed when faced with an equivocal US has been the subject of several recent studies. Some centers have opted to use CT as a standard second-line approach while other studies have been able to exclude CT radiation by employing serial exams and US imaging. There is emerging use of magnetic resonance imaging (MRI) as a second-line modality is emerging but likely requires further research before it can be standard of care.
- Something to remember, and one more reason to standardize the diagnostic approach to AA, is that higher rates of perforation have been found in minorities, patients on Medicaid, and in Hispanics with limited English proficiency. AA serves as a model disease with respect to the healthcare disparities in children given its prevalence and adverse outcomes with misdiagnosis.

Key Clinical Recommendations

Risk stratification of acute appendicitis:

- High probability acute appendicitis
    - Symptoms less than 48hrs
    - Migration of pain from periumbilical region to right lower quadrant (RLQ)
    - Anorexia, nausea, vomiting
    - Pain preceding vomiting
    - Pain with movement (cough, car ride, jumping, heel tap)
    - RLQ tenderness with or without rebound
- Equivocal acute appendicitis
    - Presenting with focal abdominal tenderness (usually right sided) with some of the features of high probability acute appendicitis
- Suspected complex appendicitis (perforation/abscess)
    - Systemic toxicity (also exclusion criteria)
    - Fever
    - Prolonged symptoms >48-72 hrs
    - Urinary or rectal urgency
    - Palpable RLQ mass
    - WBC, ANC, CRP consistent with marked inflammation

Pediatric Appendicitis Score

- Low risk <4, High risk >/= 7
    - Nausea/vomiting 1
    - Anorexia 1
    - Migration of pain to RLQ 1
    - Fever 1
    - Pain with movement 2
    - RLQ Pain 2
    - WBC >10,000 1
    - ANC >7,500 1
    - *An experienced physician's clinical impression performs comparably to this score

Laboratory evaluation:

- All patients
    - CBC with ANC
    - CRP
    - UA
- As clinically indicated
    - CMP
    - Lipase, amylase
    - Urine HCG (all female patients >11yrs)
    - Urine GC/Chlamydia, vaginal swab for Trichomonas (sexually active patients with other symptoms)
- Ill patients
    - Blood Culture
    - Coagulation Studies
    - Lactate
    - Procalcitonin
    - Type and Screen (not indicated for routine appendectomy)

Laboratory Interpretation:

- WBC >14,000 **AND/OR** CRP >1.0 is found in 95% of simple appendicitis and 100% of complex appendicitis
    - Therefore, if **both** are normal one should strongly consider an alternate diagnosis
    - If one or the other is elevated it adds little value to the diagnostic evaluation beyond contributing to the PAS score
- UA in appendicitis may occasionally demonstrate sterile pyuria
    - Leukouria without bacteria or nitrates present should not dissuaded one from the diagnosis of appendicitis

Therapeutic interventions:

- A small number of patients with equivocal risk assessment, who are well hydrated, and who do not have severe pain may NOT need IV placement and can be made NPO while awaiting their initial US
- Most patients should receive
    - NPO order
    - Peripheral IV
    - IV fluids in either maintenance or bolus form based on clinical assessment of hydration
    - Analgesia if moderate to severe pain (typically Morphine 0.1mg/kg max dose 4mg)
    - Antiemetic if vomiting (typically Zofran 0.15mg/kg max dose 4mg)
- Once appendicitis is confirmed on diagnostic imaging (or at the direction of the surgical service) antibiotics are indicated
    - Healthy non-allergic patients with Simple appendicitis (no perforation or abscess)
        - Ceftriaxone IV 50mg/kg/dose max dose 2,000mg
    - Patients with complex appendicitis (perforation or abscess)
        - Ceftriaxone IV 50mg/kg/dose max dose 2,000mg **AND**
        - Metronidazole IV 30mg/kg/dose max dose 1,500mg
    - Patients with Cephalosporin allergy
        - Ciprofloxacin IV 15mg/kg/dose max dose 400mg**AND**
        - Metronidazole IV 30mg/kg/dose max dose 1,500mg
    - Patients who are immunocompromised or very ill or confirmed to have perforation with peritonitis intraoperatively.
        - Piperacillin/Tazobactam IV 100mg/kg/dose max dose 3,000mg
        - Consider Infectious Disease consult
        - In the case of perforation with peritonitis, the piperacillin/tazobactam will be started after admission to the floor from the OR on postop day #1. Piperacillin/tazobactam should not be started in the OR, and the diagnosis will need to be clearly documented with ICD10 code K35.33 or K35.32.
    - Duration of IV antibiotics and potential discharge home on oral antibiotics and choice of oral antibiotics will depend on the clinical situation and is usually between 2-5 days for IV antibiotics.

Diagnostic Imaging: (See figure 1)

- When, after consideration of the above clinical and laboratory evaluation, one suspects the diagnosis of acute appendicitis an US appendix should be obtained
    - *It is appropriate in some patients who have a classic history and exam to defer imaging and instead obtain a surgical consultation for elective appendectomy
    - When a **positive** US for appendicitis is discovered the surgical service will be consulted, and they will direct care along with the ED provider until admission

- A **negative** US will require reevaluation and care as deemed appropriate by the ED provider with consideration of other etiologies of the patient's symptoms
- In the event of an **equivocal** US (appendix not visualized, or appendix visualized but cannot be effectively characterized by the radiologist) a reexamination of the patient is warranted.
    - Considerations for Reimaging
        - If the patient is > 11 yrs old and can tolerate approximately 15 min of non-sedated imaging
            - Consider MRI Appendicitis Protocol (non-contrast)
                - If Interpretation of "Positive RLQ Inflammation" consult Surgery
                - If Interpretation of "Negative RLQ Inflammation" treat for other conditions as indicated
                - If Interpretation is "Equivocal" consider CT Abdomen with contrast
        - If the patient is < 11 yrs old OR cannot tolerate approximately 15 min of un-sedated imaging
            - Consider imaging by CT Abdomen with contrast

- If upon ED provider reexamination
    - The provider is no longer suspicious for acute appendicitis, then care should proceed as deemed appropriate by the ED provider with consideration of other etiologies of the patient's symptoms
    - Acute appendicitis remains of concern to the provider then a surgical consult for exam will be obtained
- If upon surgical consultation/exam
    - The care team is no longer suspicious for acute appendicitis, then care should proceed as deemed appropriate by the ED provider with consideration of other etiologies of the patient's symptoms
    - Acute appendicitis remains of concern to the care team, then the patient will be admitted under the serial ultrasound pathway to the surgical service
        - Those admitted on the serial US pathway will have regular reassessments at the discretion of the surgical team
        - If, on any reassessment, clinical suspicion of appendicitis is no longer present then the patient's care and disposition will be at the discretion of the surgical team
        - If on any reassessment, more than 8 hours from initial US, clinical suspicion of appendicitis persists, the patient will have a second ultrasound performed
- If the second US
    - Demonstrates findings concerning for appendicitis, then the surgical service will proceed accordingly

- Demonstrates a negative result, then the patient's care and disposition will be at the discretion of the treatment team
- Is again equivocal, and clinical suspicion of appendicitis persists, then the care team will consider
    - An empiric appendectomy
    - Continued observation with or without additional US
    - CT or MR imaging to attempt to further confirm or exclude the diagnosis

Clinical Pathway Goals

1. Standardize the approach to diagnosing acute appendicitis at Phoenix Children's
2. Decrease the utilization of CT to diagnose acute appendicitis
3. Incorporate MRI as a potential secondary imaging modality to diagnose acute appendicitis (instead of CT)
4. Ensure timely consultation with the surgical service

Outcome Measures

1. CT rate for the diagnosis of acute appendicitis
2. Clinical pathway adherence
3. Timely notification of surgery service when indicated
4. Diagnostic accuracy of first, second, and combined USs
5. Diagnostic accuracy of MRI
6. Diagnostic accuracy of the pathway in patients with elevated body mass index (BMI)

Balancing Measures

1. Diagnostic accuracy of the pathway
    a. A **diagnostically accurate case** will be defined as one of seven potential outcomes
        i. Those with a positive initial US with confirmed appendicitis (defined above)
        ii. Those with a negative initial US and confirmed not to have appendicitis (defined above)
        iii. Those with an initial equivocal US and interval US positive with confirmed appendicitis
        iv. Those with an initial equivocal US and interval MRI positive with confirmed appendicitis
        v. Those with an initial equivocal US and interval MRI negative and confirmed not to have appendicitis
        vi. Those with an initial equivocal US and interval US negative confirmed not to have appendicitis
        vii. Those with an initial equivocal US then later found at any time to have a reassuring reassessment, discharged and confirmed not to have appendicitis

b. A **diagnostically inaccurate case** will be defined as one of six potential outcomes
    i. Those with a positive initial or interval US and confirmed to not have appendicitis
    ii. Those with a negative initial or interval US with confirmed appendicitis
    iii. Those with a positive MRI and confirmed not to have appendicitis
    iv. Those with a negative MRI with confirmed appendicitis
    v. Those discharged at any point without an appendectomy who have confirmed appendicitis
    vi. Any child who has a CT to confirm or exclude the diagnosis of appendicitis
2. Cost of care for patients before and after the intervention

Order Set

1. See "ED Acute Appendicitis" Order set

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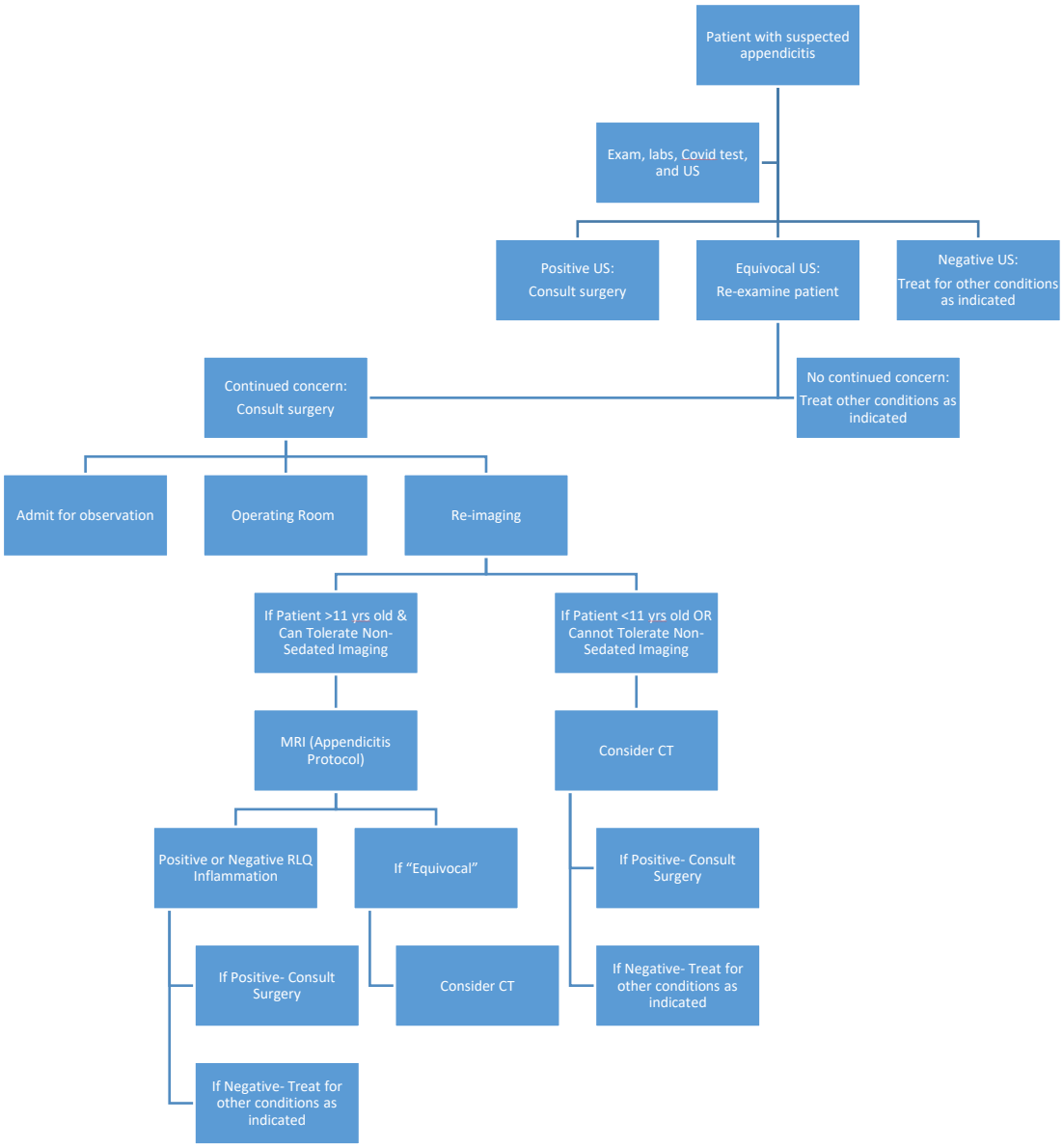
*It is appropriate in some patients who have a classic history and exam to defer imaging and instead obtain a surgical consultation for elective appendectomy

EXCLUSION CRITERIA*:
Children < 3
Toxic appearance
Hemodynamic instability
Previous appendectomy
Pregnancy
History of IBD
Trauma patients
CT done by outside institution On-going treatment for malignancy
History of organ transplant
Severe developmental delay

*It is important to recognize that **acute appendicitis can occur in ANY of the above excluded patient populations**. However, these patients will likely require different considerations in their evaluation that prevent these general recommendations from being applied to them.

Figure 1


Patient with suspected appendicitis
Exam, labs, Covid test, and US
Positive US: Consult surgery
Equivocal US: Re-examine patient
Negative US: Treat for other conditions as indicated
Continued concern: Consult surgery
No continued concern: Treat other conditions as indicated
Admit for observation
Operating Room
Re-imaging
If Patient >11 yrs old & Can Tolerate Non-Sedated Imaging
If Patient <11 yrs old OR Cannot Tolerate Non-Sedated Imaging
MRI (Appendicitis Protocol)
Consider CT
Positive or Negative RLQ Inflammation
If "Equivocal"
If Positive- Consult Surgery
If Positive- Consult Surgery
Consider CT
If Negative- Treat for other conditions as indicated
If Negative- Treat for other conditions as indicated

Stratifying Patient Risk

High probability acute appendicitis	Symptoms <48hrs
	Migration of pain from periumbilical region to RLQ
	Anorexia, nausea, vomiting
	Pain preceding vomiting
	Pain with movement (cough, car ride, jumping, heel tap)
	RLQ tenderness with or without tenderness
Equivocal acute appendicitis	Presenting with focal abdominal tenderness (usually right sided) with some of the features of high probability acute appendicitis
Suspected complex appendicitis (perforation/abscess)	Systemic toxicity (also exclusion criteria)
	Fever
	Prolonged symptoms >48-72hrs
	Urinary or rectal urgency
	Palpable RLQ mass
	WBC, ANC, CRP consistent with marked inflammation

Pediatric Appendicitis Score
Low Risk <4; High Risk ≥7

Nausea/vomiting	1
Anorexia	1
Migration of pain to RLQ	1
Fever	1
Pain with movement	2
RLQ tenderness	2
WBC >10,000	1
ANC >7,500	1
*An experienced physician's clinical impression performs comparably to this score	

Laboratory Evaluation

All patients	CBC with ANC[1]
	CRP[2]
	UA[3]
As clinically indicated	CMP
	Lipase, amylase
	Urine HCG (all female patients >11yrs)
	Urine GC/Chlamydia, vaginal swab for Trichomonas (sexually active patients with concerning symptoms)
Ill patients	Blood Culture
	Coagulation Studies
	Lactate
	Procalcitonin
	Type and Screen (not indicated for routine appendectomy)

[1,2]WBC >14,000 **AND/OR** CRP >1.0 is found in 95% of simple appendicitis and 100% of complex appendicitis
Therefore, if **both** are normal one should strongly consider an alternate diagnosis
If one or the other is elevated it adds little value to the diagnostic evaluation beyond PAS score
[2]UA in appendicitis may occasionally demonstrate sterile pyuria
Leukouria without bacteria or nitrates present should not dissuaded one from the diagnosis of appendicitis

Preoperative Antibiotics
Indicated for ALL patients with Acute Appendicitis

Healthy non-allergic patients with Simple appendicitis (no perforation or abscess)	Ceftriaxone IV 50mg/kg/dose max dose 2,000mg
Healthy patients with Cephalosporin allergy and simple appendicitis (no perforation or abscess)	Ciprofloxacin IV 15mg/kg/dose max dose 400mg**AND** Metronidazole IV 30mg/kg/dose max dose 1,500mg
Patients with complex appendicitis (perforation or abscess)	Ceftriaxone IV 50mg/kg/dose max dose 2,000mg **AND** Metronidazole IV 30mg/kg/dose max dose 1,500mg
Patients who are immunocompromised or very ill	Piperacillin/Tazobactam[1] IV 100mg/kg/dose max dose 3,000mg. Consider Infectious Disease consult