



THE ULTRASONOGRAPHIC EXAM FOR ACUTE APPENDICITIS AT PATIENT'S BED

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Abstract: Acute appendicitis is one of the most frequent surgical emergencies in children. The diagnosis of this condition is still a challenge for small pre-school children, and, generally, for children, as the wrong diagnosis is 28-57% for children between 2-12 years old. Therefore, the ultrasonographic exam for suspected acute appendicitis at patient's bed (POCUS) is a necessary and useful paraclinical exam for supporting the diagnosis. The procedure has established: the quality of use in the emergency department (ED) of POCUS by the pediatric emergency doctors; the performance of ultrasonographic exam (US) in acute appendicitis (AA); reduces associated costs for imaging studies by standardization diagnosis of acute appendicitis through ultrasonographic examination. The ultrasonographic exam can be useful in evaluating children with suspected acute appendicitis and should be first choice for imaging examination. Also, it can reduce the use of CT scan and exposure to radiation, and the annual cost for imaging exams.

INTRODUCTION

Acute appendicitis is one of the most common emergency in children (1-2 % of pediatric surgical admissions).

If it is referred to abdominal pain, acute appendicitis related with abdominal pain is about 1-8%. However, in small pre-school children the frequency is lower, only 2-9% of confirmed cases are in this range.(1)

In USA, acute appendicitis's incidence is 70.000 cases/ year.(2) The incidence by age group is 1-2 cases at 10.000 children/year, in newborn. It increases at 25 cases at 10.000 children/year between 10-17 years old. Overall, 7% of the people in USA were appendectomized by their lifetime. The male/female ratio is 2:1. Appendicitis is much more frequent in developed countries. Although the reason of this discrepancy is unclear, potential risk factors include low fiber and high sugar diet, family history and infection. Gut flora and the exposure to gastrointestinal infections were also proposed for the "hygienic theory" of appendicitis. There can also be a genetic cause correlated with intestinal microbioma in developing acute appendicitis and, eventually, there are even correlated with the risk of perforated appendicitis. Appendicitis appears at all ages, but it is rare in infants. Maximal frequency is in the second decade of life (between 10-19 years of age), 23,3 cases at 10.000 children/year. Then, the incidence is decreasing, although appendicitis also appears in adult and elderly people.

The diagnosis of acute appendicitis at small age is still a challenge despite the new and advanced imaging methods. Late presentation at the doctor's, most of the times with related complications of perforated appendicitis (abscess, peritonitis, sepsis) supports in addition diagnostics features of the condition at this age.

Late diagnosis was correlated in children with limited possibilities of expression and difficult examination, with the

probability of linking symptomatology with other conditions usual in children, which include abdominal pain as a sign.

In these circumstances, the rate of incorrect diagnosis is big, 28-57% in children within 2-12 years old, and may rise to 100% in children under 2 years of old.

Therefore, the ultrasonographic exam at patient's bed (POCUS) for suspected acute appendicitis is an equally useful and necessary paraclinical examination for supporting the diagnosis.

AIM

- Determining the usefulness of anamnestic, clinical and laboratory data, the usefulness of acute appendicitis scoring (PAS), and usefulness of the ultrasonographic exam at patient's bed for suspected acute appendicitis in emergency department (ED-POCUS);
- Establishing the quality of use in ED for POCUS by pediatric emergency doctors;
- Assessing the performance of ultrasonographic exam (US) in children in acute appendicitis (AA) and assessing the correlation of the score for acute appendicitis (PAS) and the C reactive protein (CRP);
- Comparative assessment of the US for the secondary appendicitis (SA) and for the primary appendicitis (PA);
- Reducing the cost of the imaging exam through the standardization of the AA diagnosis with US and lowering the number of CT scans.

MATERIALS AND METHODS

- POCUS technique description,
- Database exploration of the recently published reference literature regarding Point-of-care ultrasound (POCUS) (point

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CLINICAL ASPECTS

of care ultrasonographic) used for diagnosis of acute appendicitis in children.

POCUS: technique and anatomy (3)

In children and normocorporal adults the linear transducer is used; the low frequency transducer as the one with curvilinear matrix is necessary in supraponderal adults to get an adequate depth.

Point of maximal tenderness technique, putting the probe where it hurts:

- place the patient in supine position;
- place the probe over the point of maximal tenderness in the right lower quadrant (RLQ) or ask the patient to place the probe at the most painful site; if it is appendicitis and it is tender in the RLQ, they are likely pointing to the area that the inflamed appendix is irritating the peritoneum,
- use “graded compression” until landmarks are visualized - the right psoas (P) muscle and iliac vessels (Ia and Iv) and/or appendix, which will appear as a blind-ended pouch; the appendix is found either in between these structures or anteriorly to these structures; an appropriate degree of compression moves gas and bowel out of the plane of the ultrasound, bringing the appendix closer to the abdominal wall, making it more easily visualized,
- once visualized, we should confirm that it is the appendix by visualizing in both transverse and longitudinal plans; the appendix should be an uninterrupted tubular structure,
- measure the appendix and compress; a normal appendix is < 6mm in diameter (< 6 to 7 mm, described in some literature for pediatrics, from outer wall to outer wall) and compressible; in a non-cooperating child who is in pain, consider analgesia before starting the examination; one can try the distraction with funny TV movies on the TV set in the examination room or games on the smartphone.

Findings in acute appendicitis:

- outer diameter greater than 6-7 mm,
- non-compressible overlying appendix area (attention: it might be compressible if the appendix is perforated!),
- lack of peristalsis.

For visualising the point of maximal tenderness technique and also introducing the “mini-lawnmower” technique.(4)

The literature uses a cut-off of 6-7 mm for the transversal diameter; however, new-borns, infants and pre-school children may have a smaller diameter, so the growth of the appendix should be considered at smaller dimensions, such as the ones at 3 to 6 years. Due to this fact we need to look for secondary findings of appendicitis, especially in pediatric patients who may have normal diameter (6 mm) which does not exclude the appendicitis.

Secondary findings in acute appendicitis:

- the presence of appendicoliths/fecaliths within the lumen, appearing as a hyperechoic structures with shadowing;
- free fluid surrounding the appendix, which appears as hypoechoic material, representing edema or perforation;
- a “Ring of Fire” image – increased vascularity using color-flow Doppler examination.

Other findings can be associated with acute appendicitis:

- wall appendix’s thickness > 3mm;
- Targer sign aspect: hypoechoic center (fluid) surrounded by hyperechoic ring (mucosa/submucosa), surrounded by echoic ring in axial view;
- increased echogenicity of adjacent periappendiceal omentum’s fat;
- enlarged mesenteric lymph nodes;
- thickening and hyperechogenicity of overlying peritoneum;

- dilated and hypoactive small bowel;
- increased (dilated apical) cecal pole or adjacent small bowel.

When the appendix cannot be found)?

If there are still difficulties in finding the appendix, Sivitz, (5) described a systematic approach to be tried in patients suspected to have acute appendicitis:

1. Move the probe laterally, until identify the ascending colon and lateral abdominal wall - the ascending colon is a non-peristalsing structure containing gas and fluid, or “dirty shadowing” (fecals); can also visualize haustra as you follow the colon down to the cecum.
2. Move the transducer on the lateral border of the cecum.
3. Then, move the transducer medially, across the psoas and iliac vessels.
4. With the psoas muscle and iliac vessels kept in view, move the transducer down into the pelvis and towards the umbilicus at the border of the cecum.
5. If the appendix is not yet visualized, put the probe in the sagittal position, identifying the cecum in the long axis and move the transducer (sweep medially) compressing the cecum against the psoas muscle.

If you still cannot visualize the appendix (it can be retrocecal), one study shows that visualization of the appendix is improved by 21,5% if following a 3-step technique:

1. The first step is the usual technique as it was described above.
2. Another technique is to place the left hand dorsally to the RLQ (placing the hand on the patient’s lumbar right zone); the user pushes against the patient’s back with pressure to anterior and anteromedial with the 4 fingers of the left hand; this technique improved visualization by 10% in one study from 2002 by JH Lee and co.(6)
3. Place the patient in a 45° left posterior oblique (LPO) position and scan parasagittal through the right flank in a coronal plane parallel to long axis of the psoas muscle; the appendix will appear anterior to (in front of) the psoas muscle.
4. If the appendix is still not visualized, the patient is returned to the supine position for repeating the examination.(7)

RESULTS AND DISCUSSIONS

Another study suggests (8) the integration of the ultrasound exam in a diagnostic algorithm to obtain a safer acute appendicitis diagnosis in children. The algorithm is first integrating the “ultrasound examination” to reduce the use of ionizing radiation in child. The clinician first uses a POCUS. This is then followed by an ultrasound exam. For those patients who have positive ultrasound exam, surgical consultation is required. For those who have negative ultrasound exam, they should go home. For the ultrasound exam when you cannot visualize the appendix, the CT scan must be done.

The study is suggesting that POCUS can diagnose the acute appendicitis, without performant ultrasound, CT or IRM done by an imagist. Nevertheless, if POCUS is equivocal or negative, the acute appendicitis cannot be excluded without further investigation.(9)

The study brings one first review of the literature to evaluate the precision of POC ultrasound in the diagnosis of acute appendicitis. The study identifies 21 studies for which a meta-analysis shows high sensitivity and specificity. The data obtained, although they are limited by the quality of the original study, suggest that the point of care in the hands of one skilled operator is an initial imagistic method suitable for diagnosing acute appendicitis. Because POCUS is not an exhaustive test or an exclusion test, the patients with a high level of suspicion of

CLINICAL ASPECTS

acute appendicitis and negative ultrasound request further imaging examinations.(10)

The ultrasound is preferred to the CT scan for the diagnosis of acute appendicitis in children because we must avoid excessive exposure to radiations.

The study shows the author's experience in establishing a template of ultrasound examination for acute appendicitis, which has reduced the number of CT scans by 67,3%. The study shows cost reduction with this template.(11)

The study is investigating the accuracy of the ultrasound exam done by the pediatric emergency doctors in children with suspected acute appendicitis. Thirteen pediatric emergency doctors have done 264 ultrasonographic studies, including 85 cases of children with appendicitis (32%). Results show that POCUS has 85% sensitivity, 93% specificity, positive probability report of 11,7, negative probability report of 0,17. In conclusion, pediatric emergency doctors with an adequate training can diagnose acute appendicitis with substantial accuracy.(5)

The study is identifying patients who had an ultrasonographic exam with gradual compression for suspected acute appendicitis in the first period of 6 months (period 1 = 419 patients) and then, (period 2= 486 patients) before implementing the new 3-step positional algorithm.

The algorithm included the initial scan in supine position (step 1), and if the appendix was still not visualized the oblique posterior scan (step 2) was performed, and then one more exam in supine position (step 3) – “the second aspect of supine position exam”. The CT scan was done within 7 days from the ultrasound exam. In conclusion, implementing one algorithm of ultrasound exam with sequential positioning has improved the rate of visualizing the appendix and the rate of diagnosis of acute appendicitis based on ultrasound, allowing a decrease of using CT abdominal scan in adults and children.(12)

CONCLUSIONS

For suspected acute appendicitis, none of the anamnesis and clinic reasons (history, physical exam, laboratory exam, PAS score) can remove the need of imaging study.

The ultrasound exam can be useful for evaluating children with suspected acute appendicitis, regardless of age, gender, and should be the first choice for imaging exam.

Combining POCUS exam with PAS and CRP can reduce the number of useless admissions for hospital observation.

A heterogeneous group of emergency doctors can identify acute appendicitis by POCUS exam, in a safely mode, with high specificity in patients with moderate to high pretested probability. The results are added as support to surgical consultation.

For emergency patients with suspected acute appendicitis, a positive POCUS exam allows avoiding unnecessary negative CT scan, but a negative exam is not sufficient to exclude acute appendicitis.

The ultrasound exam for acute appendicitis reduces:

- the using of CT scan and the exposure associated with radiations;
- annual costs for imaging studies, despite the high number of imaging studies (excluding CT).

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