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Imaging in Suspected Appendicitis

Jaime A. Fandiño Romero and
Fernando Meléndez Negrette

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Abstract

Appendicitis is the most suspected diagnosis in patients who consult for abdominal pain, and appendicitis is the most common cause which requires urgent abdominal surgery or intervention. Classically, the diagnosis has been made with the patient's medical history, physical examination, and laboratory findings; however, its preoperative diagnosis is increasingly reliant on imaging. The negative appendectomy rates decreased after the introduction of the use of imaging modalities. The diagnosis of appendicitis should be made early to avoid complications such as perforation. The objective of this chapter is to describe briefly the most important findings in each available image modality and the impact they have on the management and list the potential mimics of appendicitis.

Keywords: appendicitis, compression ultrasound, multidetector computed tomography, magnetic resonance imaging, abdominal imaging

1. Introduction

Appendicitis in a common surgical problem is the most frequent cause of acute abdominal pain [1].

Using the clinical scoring system Alvarado with a low score of 1–4 only, some patients should be considered for imaging. Those with Alvarado score of 5–7 should have imaging performed [2].

2. Diagnostic imaging

In all patients who have clinical suspicion of appendicitis, we have various modalities of images to either confirm the diagnosis or rule out other causes of abdominal pain and reduce the rate of negative appendectomies such as ultrasound (US), computed tomography (CT), magnetic resonance, and conventional radiography in some cases.

In this chapter we will review the most common findings in each modality of diagnostic imaging.

It is important to know the normal location of the appendix to know where we can find it at the diagnostic images; the location of the base is relatively constant, while the location of the tip is more variable due to its variable length.

The tip of the appendix will be located behind the cecum (ascending retrocecal) 65%, inferior to the cecum (subcecal) 31%, behind the cecum (transverse retrocecal) 2%, anterior to the ileum (ascending paracecal preileal) 1%, and posterior to the ileum (ascending paracecal retroileal) 0.5% [3].

2.1. Conventional radiography

They are not of routine use for the diagnosis of acute appendicitis due to their low specificity. The main finding in this imaging method is the presence of appendicolith, which is visible in less than 5% of patients with acute appendicitis, and its presence does not always indicate acute appendicitis and is not indicative of prophylactic appendectomy in children and adults.

Other nonspecific findings are abnormal gas pattern in the right iliac fossa, gas pattern in the right lower quadrant (ileocecal part or ascending colon topography) of the Klemm's sign [4], the presence of a sentinel loop, and loss of the right psoas margin. The use of barium would show indirect signs such as lack of filling of the appendiceal lumen or extrinsic impression of the cecum by an appendiceal abscess [5–8].

2.2. Ultrasound (US)

Ultrasound has had many advances in the last 30 years, and although it is a dependent operator, it is quite useful in the pediatric population and pregnant women for not using ionizing radiation; it has a very low cost and is very accessible.

The ultrasound has a sensitivity of 78 and 83% and a specificity of 83 and 93% [9], which is similar to those reported for physical examination or validated clinical scores such as the Alvarado score, but this one is variable and depends on age; an Alvarado score cut point of 5 was good at "ruling out" admission for appendicitis with a sensitivity of 99% overall (96 men, 99 women, and 99% children). At a cut point of 7 (historically recommended for "ruling in" appendicitis and progression to surgery), the score performed poorly with specificity overall of 81% (men 57, women 73, and children 76%). The Alvarado score was well calibrated in

men; however, it tended to overpredict appendicitis in women and children subgroups. The standard Alvarado scoring is useful in areas with limited resources and no imaging diagnostic tools [10].

In the graded compression technique described by Puylaert in 1986 with a linear high-frequency transducer, pressure is applied in order to displace gas-filled loops of bowel [11]. Another technique can be used, like left lateral decubitus position for retrocecal position. About 23% of normal appendices are larger than 6 mm according to one ultrasound-based study; for this reason some institutions use a threshold of 7 mm [12].

The ultrasound findings are aperistaltic, noncompressible, dilated appendix (>6–7 mm outer diameter), one or more appendicoliths with echogenic shadowing foci, target appearance in axial section, distinct appendiceal wall layers (**Figure 1**), and occasionally extra-appendiceal changes like echogenic prominent pericecal and periappendiceal fat, hyperechoic structure surrounding a noncompressible appendix (**Figure 2**), and periappendiceal reactive nodal enlargement or fluid collection [13].

Color Doppler ultrasound shows increased vascularity (**Figure 3**) or decreased if ischemia is present.

In the description of the severity of inflammation real time ultrasound elastography can be useful [14].

The limitations and disadvantages of the ultrasound are well known like it is operator dependent and requires years of training. The appendix is not always visualizable especially in retrocecal position and the presence of bowel gas. Another limitation is the reduced penetration of ultrasound in obese patients.

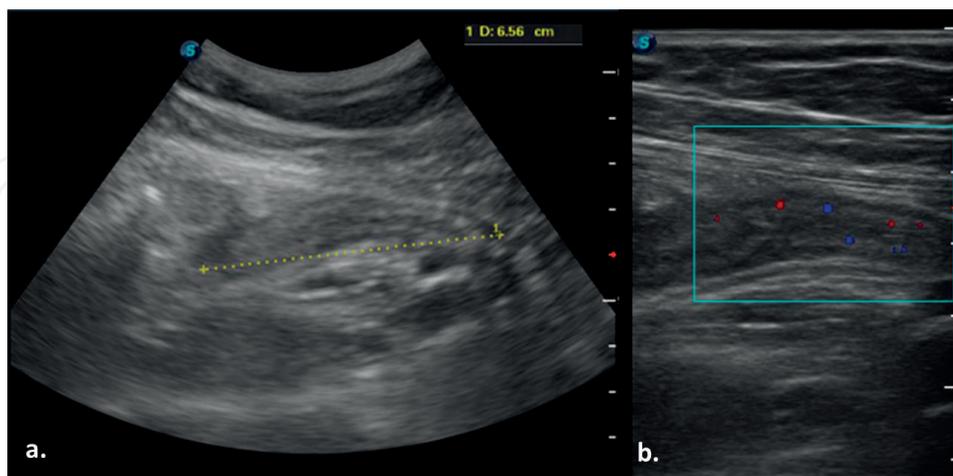


Figure 1. Graded compression sonography images in longitudinal sections (a) of an enlarged, noncompressible appendix compatible with no complicated appendicitis. Color Doppler flow image (b) demonstrated increased blood flow in the wall of the inflamed appendix due to hyperemia.

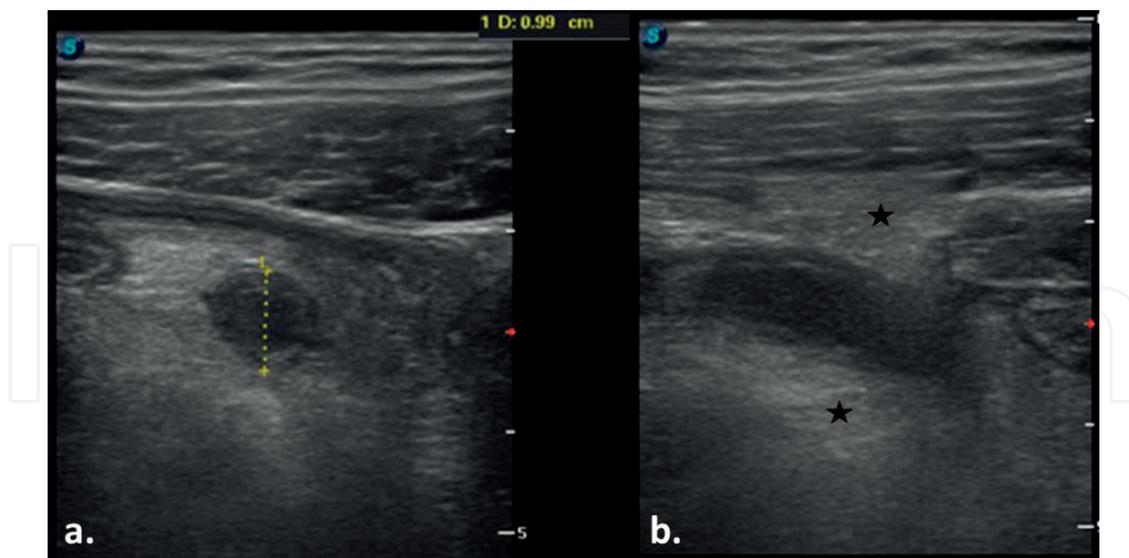


Figure 2. (a) Target appearance (axial section) of periappendiceal hyperechoic structure: Amorphous hyperechoic structure (usually >10 mm) seen surrounding a noncompressible appendix with a diameter of >6 mm. (b) Thickened appendix in longitudinal image and echogenic prominent periappendiceal fat (black stars).

2.3. Multidetector CT

For evaluating patients with signs and symptoms of acute appendicitis, controversy about which CT protocol is better exists, and the use of intravenous (IV), oral, and rectal contrast agents is debated. The options include the use of intravenous contrast material alone, oral contrast material alone, rectal contrast material alone, or no contrast material at all [15].

The use of oral contrast material has advantages like allowing a decreased number of false negatives, and appendiceal filling is suggestive of non-obstructed appendix. The disadvantages are increase in the scanning time and delay patient care, the oral contrast can mask appendicoliths, discomfort for the patient, and higher cost of the imaging examination.

At our hospital, patients with suspected appendicitis undergo CT without contrast material. What is important is that the chosen protocol should be appropriate for each particular patient.

Minimize the patient's exposure to radiation as much as possible; applying ALARA (as low as reasonably achievable) principle is always recommendable [16].

The sensitivity and specificity of CT are high (94–98%) and specific (up to 97%), respectively, for the diagnosis of acute appendicitis and can help for differential diagnosis [17].

CT diagnosis of appendicitis can include some of these findings like dilated appendix (>6 mm), thickening and enhancing of the wall, and thickening of the cecal apex (**Figure 4**) and extra-appendiceal findings like extraluminal fluid, abscess formation, appendicolith (**Figure 5**), and periappendiceal inflammation, including stranding of the adjacent fat (**Figure 6**) and thickening of the lateroconal fascia or mesoappendix or reactive nodal enlargement [18].

For the differentiation of complicated from uncomplicated, the CT plays an important role.

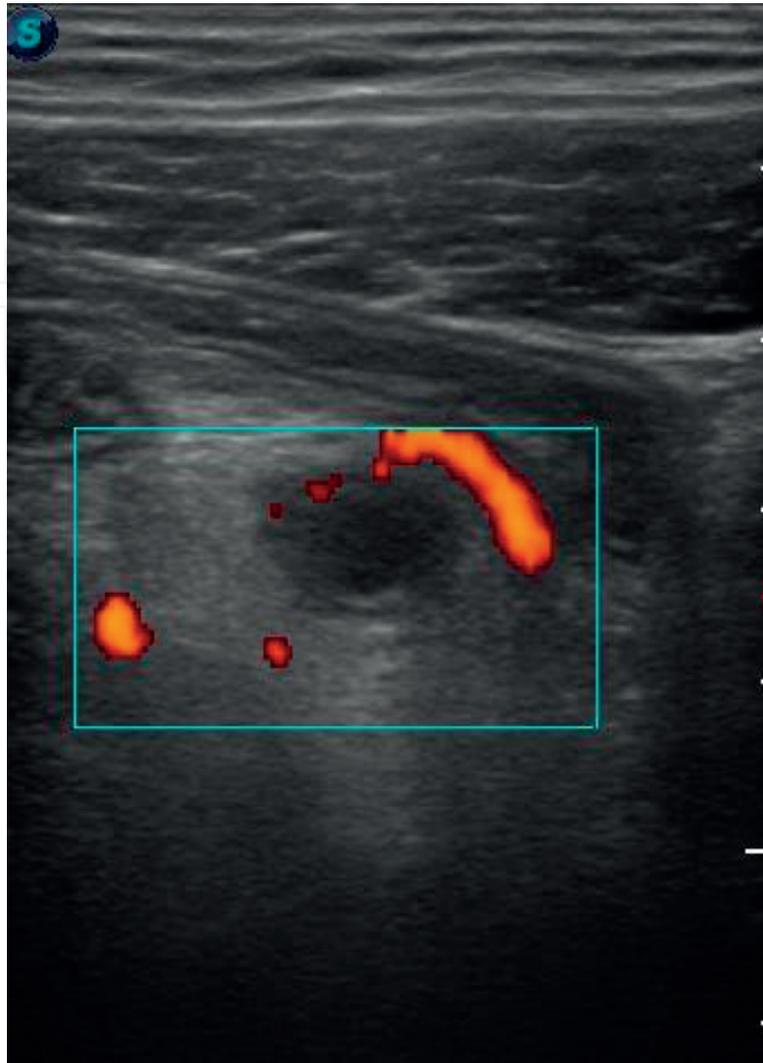


Figure 3. Axial US image with power Doppler shows increased vascularity.

Although it may be difficult to differentiate a simple appendicitis from a perforated appendicitis, there are some classics of CT findings of perforated appendicitis like extraluminal air, the presence of one or more extraluminal appendicolith, abscess, phlegmon, and defect in mural enhancement (highest sensitivity at 64%); these five findings collectively have a 95% of sensitivity and specificity for a diagnosis of perforated appendicitis [19].

2.4. Magnetic resonance imaging

Magnetic resonance imaging (MRI) is not commonly used to diagnose appendicitis but lacks of effects of ionizing radiation, which makes it ideal for pregnant patients and children with symptoms of appendicitis and equivocal US findings.

In pregnant patients, the clinical diagnosis of appendicitis can be difficult, the location of pain may be atypical, and the classics symptoms are nonspecific. A negative appendectomy is associated with a higher risk of fetal loss and premature delivery.

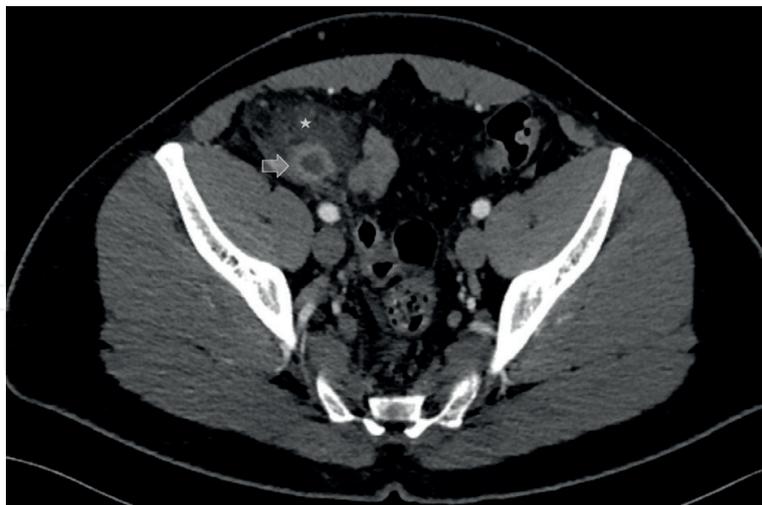


Figure 4. Axial Multidetector CT (MDCT) image with intravenous contrast in a man with suspected appendicitis. The appendix (white arrowheads) is fluid filled, showing an increased caliber (>6 mm) (target sign), extra-appendiceal findings of periappendiceal inflammation, and stranding of the adjacent fat (white star).

The appendix can be difficult to visualize with ultrasound in a pregnant patient, MRI has excellent anatomic resolution, and it is safe in these patients.

MRI is most expensive, takes longer time to be performed, and also can be degraded by motion artifacts.



Figure 5. Coronal CT with intravenous contrast image showing the presence of an appendicolith on the same patient (white arrow).

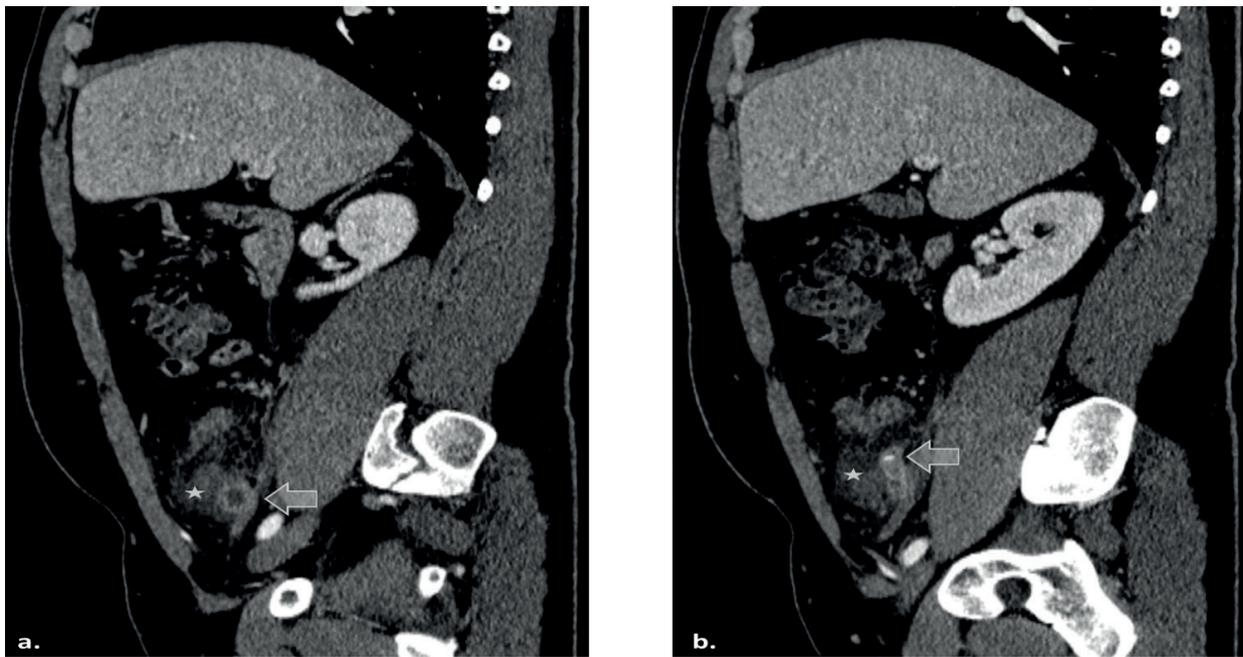


Figure 6. Sagittal CT image: (a) the appendix (white arrowheads) shows target sign, periappendiceal inflammation, and stranding of the adjacent fat (white star). (b) Appendicolith.

MRI is considered to provide positive results for acute appendicitis when the appendix is enlarged (>7 mm), the appendiceal wall is thicker than 2 mm, or there are signs of inflammatory changes (**Figure 7**).

It is important to remind that although MRI is safe during pregnancy and no fetal effects have been documented, no IV contrast should be used during pregnancy because gadolinium is a category C drug (potentially teratogenic) [20].

MRI is a promising modality in the evaluation of suspected acute appendicitis despite the fact that its reliability in differentiating perforated from simple appendicitis has considered in some

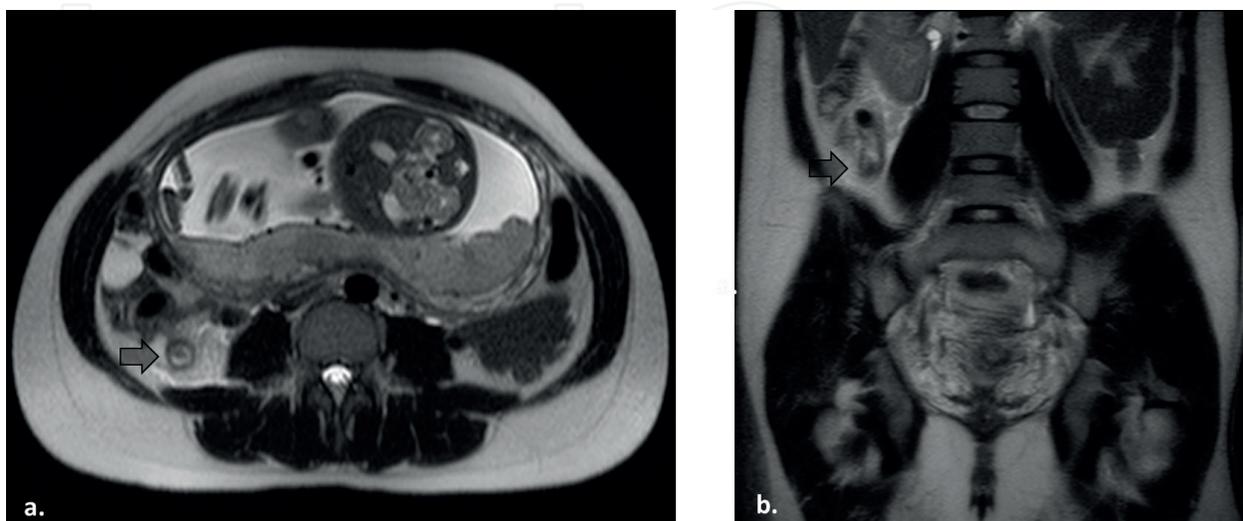


Figure 7. (a) Axial and (b) coronal MR scan with T2-weighted coronal image of the abdomen in a gravid woman. Arrow highlights the thickened appendix.

cases unsatisfactory and MRI findings predictive of appendiceal perforation have not been specifically evaluated clearly; some authors recently have established that contrast-enhanced MRI can differentiate perforated from non-perforated appendicitis in pediatric population based on the appendiceal diameter and another MRI finding like appendiceal restricted diffusion, wall defect, appendicolith, periappendiceal free fluid, remote free fluid, restricted diffusion within free fluid, abscess, peritoneal enhancement, ileocecal wall thickening, and ileus. Abscess, wall defect, and restricted diffusion within free fluid had the greatest specificity for perforation but low sensitivity, and a threshold of any four findings mentioned had the best ability to accurately discriminate between perforated and non-perforated cases, with a sensitivity of 82% and specificity of 85% [21].

3. Complicated appendicitis

One of the main objectives of the diagnostic images is to contribute to the early diagnosis to avoid possible complications, and the differentiation of complicated from uncomplicated is important to define the definitive treatment. The possible complications include perforation which we have already mentioned and the role of computed tomography, ultrasound, to

US	CT
ACUTE APPENDICITIS	
Enlarged appendix(greater than 6 mm)	Enlarged appendix
Wall thickening	Wall thickening
Appendicolith	Appendicolith
Target sign	Target sign
Periappendiceal lymphadenopathy	Periappendiceal lymphadenopathy
Blind ending aperistaltic tubular structure	Periappendiceal fat strading
	Wall enhancement
	Focal apical thickening
PERFORATED APPENDICITIS	
Appendiceal wall defect	Appendiceal wall defect
Abscess	Abscess
Extraluminal appendicolith	Extraluminal appendicolith
Periappendiceal fluid collection	Periappendiceal fluid collection
	Extraliminar air
	Phlegmon

Table 1. CT and ultrasound findings of simple and perforated appendicitis.

differentiate between simple and perforated appendicitis are listed in **Table 1**; another complication can include abscess, peritonitis, pylephlebitis and pylethrombosis, genitourinary involvement (hydronephrosis), and gangrenous appendicitis (pneumatosis, shaggy appendiceal wall, and patchy areas of mural nonperfusion) [22]. Other complications can be bowel obstruction, chronic and recurrent appendicitis, or rare complication like fistulation [23].

4. Secondary or reactive appendicitis

There are some inflammatory conditions that can lead to the development of appendicitis, and although they are not frequent, it is important to mention them; each of these entities has specific findings in the diagnostic images affecting the appendix, and computed tomography plays a fundamental role by differentiating each of them.

The causes of secondary appendicitis can be Crohn's disease, diverticulitis, colitis, terminal ileitis, and gynecologic causes like tubo-ovarian abscess or pyosalpinx.

For all these entities, the clinical context associated with the appendicular involvement evidenced by images is of vital importance for the diagnosis.

5. Differential diagnosis

Differential diagnosis can include mesenteric adenitis (clinically the most common differential and most frequent in children and adolescents), and features on CT and ultrasound include enlarged lymph nodes (three or more), normal appendix if can be identified, and ileal or ileocecal wall thickening [24, 25].

Other differentials can be enlarged normal appendix (50 of asymptomatic patients can have an appendix diameter greater than 6 mm on CT), Crohn's disease, appendiceal mucocele, pelvic inflammatory disease (PID), acute epiploic appendagitis, omental infarction, Meckel's diverticulitis right-sided diverticulitis, and appendiceal neoplasms (carcinoid, metastases, and others) [26].

Except for mesenteric adenitis in children, tomography is the modality of choice that allows us to perform an adequate differential diagnosis.

6. Conclusion

Appendicitis is still one of the most common diagnoses in emergency rooms, the Alvarado score has a good diagnostic utility at specific cutoff points, and after performing a clinical diagnosis, the imaging in these patients with suspected appendicitis has become almost mandatory; the choice of one modality of image or another depends on the profile and context of each patient, ultrasound as being very important in the pediatric population and pregnant women. MRI is important if the ultrasound is nondiagnostic. CT is the modality of choice for most adults and can perform an adequate differential diagnosis.

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Conflict of interest

We have no conflict of interest to declare.

Author details

Jaime A. Fandiño Romero* and Fernando Meléndez Negrette

*Address all correspondence to: jaimeandresfr@hotmail.com

Radiology Department, Hospital of the Universidad Del Norte, Barranquilla, Colombia

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