REVIEW ARTICLE

DIAGNOSIS OF APPENDICITIS – RADIOLOGICAL EVALUATION

P. S. Mishrikotkar[1], R. J. Totla[2], Haseeb[3], Jyoti Rai[4], Gaurav Sharma[5], Sarvesh Patil[6]

HOW TO CITE THIS ARTICLE:
P. S. Mishrikotkar, R. J. Totla, Haseeb, Jyoti Rai, Gaurav Sharma, Sarvesh Patil. "Role of the Health-Care Professionals in Combating Tobacco Epidmics". Journal of Evidence Based Medicine and Healthcare; Volume 1, Issue 8, October 15, 2014; Page: 925-936.

OVERVIEW: The appendix is a blind-ending tubular structure arising from the cecum. Appendicitis results from an acute inflammation of the appendix and creates the most common abdominal surgical emergency. A diagnosis of acute appendicitis is usually made on the basis of a patient's clinical history in conjunction with physical examination and laboratory studies. Because the surgical aim is to operate early - before appendiceal rupture and peritonitis —patients who present with typical findings undergo immediate surgery without radiologic evaluation. However, such imaging is advisable in patients with atypical symptoms, which can occur in infants and small children, the elderly and young women. **DESIGN:** Prospective trial. **MATERIALS & METHODS**: PATIENTS: One hundred twenty three patients admitted or referred in the department of Radiology with suspected appendicitis from May 2011 to June 2013. **AIMS & OBJECTIVES:** The use of ultrasonography has increased in the evaluation of acute abdominal pain & its efficacy & correlation of findings.

Inclusion & Exclusion: All patients in pain in rt. Lower abdomen are included. Patients with bleeding per vagina excluded, as thought to be genitouretery etiology & suspected non appendiceal pathology.

Preferred Examination: Controversy exists as to whether imaging is required in patients with the classic history and physical findings of acute appendicitis. Opinion varies as to whether these modalities should be performed in all patients with suggested appendicitis or if radiology should be reserved for select patients with atypical or confusing clinical presentations. But imaging confirmation of the disease is always helpful in minimizing possible errors.

Multi detector computed tomography (MDCT) scanning and graded-compression Doppler ultrasonography (US) are powerful imaging methods that substantially improve diagnostic accuracy in patients with clinically equivocal appendicitis.[2, 7, 11]

In initial days, before the 1980s, abdominal radiographs and barium study were the primary radiologic methods used in the diagnosis of acute appendicitis[5] On plain radiographic films, the presence of an appendicolith is the most specific sign, but it is rarely observed. E/o sentinel loops in right iliac fossa can be considered for possible appendicular pathology. On barium enema examination, non-filling or incomplete filling of the appendix indicates appendiceal inflammation.

Multiple studies have found that the sensitivity of a barium enema study is in the range of 80-100%. However, as many as 16% of studies in adults (22-39% in children) were technically unsuitable for interpretation and excluded from data analysis.

Continuous improvements in imaging technology, technique, and interpretation that have been achieved over the past 15 years have substantially increased the accuracy of imaging methods. Since 1986, ultrasound and, after the 1990s, CT scanning have gained acceptance as the primary imaging techniques for acute appendicitis by virtue of their ability to directly image the appendix, adjacent fat, and gut.

Graded-compression ultrasound of the right lower quadrant (RLQ) has been shown to be a useful examination because of this technique's safety and high accuracy (approximately 90%) in the diagnosis of acute appendicitis[1,20,26] Advantages of ultrasound include lack of radiation exposure, noninvasiveness, short acquisition time, and the potential for diagnosis of other causes of abdominal pain, particularly in the subset of patients who are women of childbearing age.[17,27] Several authors suggest that US should be the first imaging method used in pregnant women and pediatric patients because x-ray exposure is especially undesirable in these groups.

Contrast-enhanced, thin-section (0.5 mm) CT scanning has become the preferred imaging technique in the diagnosis of acute appendicitis and its complications, with a high diagnostic accuracy of 95-98%. The literature suggests that limited helical CT scanning with rectal contrast is a highly accurate, time-efficient, cost-effective way to evaluate adult patients with equivocal presentations for appendicitis.[11,18] CT scanning is particularly preferred in patients in whom appendiceal perforation is suspected, because the diagnostic accuracy remains high and because CT scanning is useful for characterizing periappendiceal inflammatory masses.

Other advanced radiologic examinations, such as magnetic resonance imaging (MRI), scintigraphy, and color Doppler US,[15,17,22] have been used in the diagnosis of acute appendicitis (see the images below), with a diagnostic accuracy of approximately 91-95%. Currently, no practical role exists for MRI and scintigraphy in acute appendicitis.

Indications: Patient with history of rt. Lumbar/iliac fossa pain who is suspected to have appendicitis could benefit from sonographic imaging of their appendix. Ultrasonography has higher reported specificities or can help delineate other abdominal or pelvic pathology. These populations include pediatric patients (as previously stated), females, and slender patients. Ultrasonography should be the first radiologic study obtained in the diagnostic work-up of such patients. Ultrasound may help delineate pathology in the abdomen or pelvis of female patients who present with right lower quadrant pain such as tubo-ovarian masses / abscesses, ovarian cysts, ectopic pregnancy, or other pathology of the female reproductive system. The other causes include renal or ureteric calculi, infections, colitis, typhilitis.

Although there are no known studies specifically addressing ultrasound for appendicitis in nonpregnant female patients, subgroup analyses show specificities of 85%-100% in selected studies.

Additionally, there have been various studies demonstrating that patients with lower body mass indexes have higher rates of detection of appendicitis using ultrasound. Although these were primarily pediatric studies, the same general concepts could be extrapolated to adult patients (male or female) even though no current studies exist in adults looking at BMI.

Computed Tomography: CT scanning has the advantage of direct visualization of the appendix, as well as the periappendiceal and other intra-abdominal structures. CT scan evaluates an abnormal appendix and the nature, severity, and extent of the associated inflammatory process.

Advantages of CT scanning: Especially with multidetector CT scan with include its superior sensitivity and accuracy compared with those of other imaging techniques, ready availability, noninvasiveness, and potential to reveal alternative diagnoses. In a study by Pickhardt et al, CT scanning is confirmed as a valuable test for confirming acute appendicitis in adults. During this study of 2871 patients, 675 had acute appendicitis. Multidetector CT scanning had a sensitivity value of 98.5%, a specificity value of 98%, a negative value of 99.5%, and a positive predictive value of 93.9%. Multidetector CT scanning also suggested an alternative diagnosis in 893 patients without appendicitis or appendectomy. Disadvantages include radiation exposure, potential for anaphylactic reaction if intravenous contrast agent is used, lengthy acquisition time if oral contrast is used, and patient discomfort if rectal contrast is used.

The typical findings are a nonfilling appendix with distension and thickened walls of the appendix and the cecum, enlarged mesenteric nodes, and periappendiceal inflammation or fluid

Ultrasonography: Ultrasound is an evasively & widely available and cheaper modality which has the potential for highly accurate imaging in patients with suspected acute appendicitis.

With the introduction of graded-compression ultrasound by Puylaert in 1986, the diagnostic use of this modality in acute appendicitis has increased dramatically.

Advantages of ultrasound are – easily & wide availability, non-invasive, no radiation exposure, short time taken for study, and potential for the diagnosis of other causes of abdominal pain, particularly in women of childbearing age. Hence ultrasound is the initial imaging modality in pregnant women and in pediatric patients, because radiation exposure is particularly undesirable in these groups.

In a retrospective study, carried out on 1, 228 children with suspected appendicitis the use of a staged protocol using first ultrasound, and subsequently CT, only if the findings were equivocal[Results showed that, in children with suspected acute appendicitis, the protocol of US first and then CT was highly accurate and may reduce the need for CT and thus exposure to radiation (sensitivity, 98.6%; specificity; 90.6%). The negative appendectomy rate was 8.1% (19 of 235 patients). The missed appendicitis rate was less than 0.5% (1 of 631 patients). CT was avoided in more than half (333 of the 631 patients) in whom the protocol was followed and the ultrasound findings were definitive, representing a substantial reduction in radiation exposure to this population.

One study suggests that ultrasonography should be incorporated as a first-line imaging modality for the diagnosis of acute appendicitis in adults. In this study, 151 patients with suspected appendicitis underwent the designed protocol. Graded-compression US was performed first. Patients with positive results on graded-compression US underwent surgery.

Patients in this study who had inconclusive or negative results underwent contrast-enhanced, multi detector CT scanning. Patients with positive findings on CT scanning also underwent surgery. Patients with negative CT scan findings were admitted for observation.

Positive ultra sonographic results were confirmed at surgery in 71 of 79 patients, and positive CT scan results were confirmed in 21 patients. Thirty-nine patients with normal CT scan results recovered and did not require surgery. The sensitivity and specificity of this protocol was 100% and 86%, respectively.

Poortman et al concluded that this diagnostic pathway, using primary graded-compression US and complementary multi detector CT scanning, yields a high diagnostic accuracy for acute appendicitis, without adverse events from delay in treatment. Although US is less accurate than CT scanning, it can be used as a primary imaging modality and avoids the disadvantages of CT scanning. Observation is safe for patients with negative findings on US or CT scanning.

The principal disadvantage is that US is operator dependent. Because non visualization is interpreted as a non-inflamed appendix, technical expertise and commitment to a thorough examination are essential in obtaining maximum sensitivity.

Ultrasonographic Technique: Ultrasound examination should be done in thorough from lungs to pubic region & at times inguino scrotal region in males evaluating the abdominal and pelvic organs.

In women with low pelvic tenderness in whom the appendix is not visualized on transabdominal ultrasound or in whom the diagnosis is not evident after abdominal and pelvic examinations have been performed, transvaginal ultrasound examination should be done. This rules out other pathologies like ectopic pregnancy, tuboovarian masses. Pelvic appendicitis is best demonstrated in women with endovaginal US; Posterolateral, oblique or decubitus approach is suggested to evaluate the retrocecal area for retrocecal appendicitis.

In 1986, Puylaert (1) described a graded-compression technique for evaluating the appendix with transabdominal ultrasound 3-5-MHz multifrequency transducer is used. Gentle, but firm, pressure is applied on the RLQ to displace intervening bowel gas and to decrease the distance between the transducer and the appendix, improving image quality. Even normal appendix can be seen in thin patients with this technique. An outer diameter of greater than 6 mm, noncompressibility, lack of peristalsis, or periappendiceal fluid collection characterizes an inflamed appendix. Left lateral decubitus, Posterolateral approach is suggested to evaluate the retrocecal area and transvaginal ultrasound women with low pelvic tenderness, if the appendix is not visualized on transabdominal study.

Graded-compression ultrasound examination (28) of a patient who may have peritoneal irritation and sensitivity. Point of maximum tenderness can provide an important diagnostic clue, which is often useful in focusing the ultrasonographic examination on the correct area in a patient with suspected appendicitis.

ULTRASOUND OF THE APPENDIX PROTOCOL

Indications

- Focal RIF pain
- Rebound tenderness
- Pelvic pain
- Elevated WCC (white cell count)

LIMITATIONS:

Bowel gas and patient with obesity are the biggest limiting factors in visualization of appendix.

Up to 60% of appendix' are retrocaecal and thus may be obscured. Not identifying an appendix does NOT exclude appendicitis.

Teaching points:

1. A step-wise technique improves the chances of visualization of the appendix.
2. There are often several causes for the non-visualization of the appendix in children.
3. A pathological appendix has characteristic US signs, with several secondary features also identified.
4. There are multiple common differentials to consider in the pediatric patient.

Imaging technique: Ultrasound examination requires first clinical assessment of the patient, short history & actual palpation Use of abdominal & high frequency probes should be used & if requires transvaginal probe in women.

Graded-compression ultrasound technique is performed using high- resolution linear transducer to displace and compress underlying bowel loops. Stepwise approach should be done.

Step 1: Displacing small bowel loops out of the way by gentle compression of the anterior abdominal wall using the ultrasound transducer The displacement of the bowel structures should allow the visualization of the iliac vessels in the right iliac fossa as well as the psoas muscle. Two-plane scanning is performed (longitudinal and transverse).

Step 2: Visualization of the ascending colon and caecum - The ascending colon is visualized with visualization of caecum, ilio-caecal junction containing gas and fluid in the right side of the abdomen. The probe is then moved inferiorly toward the caecum, using repeated compression and release to express gas and fluid from the bowel. The right psoas muscle should also be visualized.

Step 3: Identification of the appendix -- Once the caecum is identified, the appendix should be visualized arising from it, in paracecal retrocecal, or any other locations separate to the terminal ileum. The appendix should be followed along its whole length. A normal appendix should measure 6 mm or less in diameter from outside wall to outside wall. It should have a thin wall (less than 3 mm), be empty or gas/faecal-filled and compressible, and there should be no evidence of hypervascularisation

Step 4:

Criteria for diagnosing acute appendicitis -

a) Compressibility: in acute appendicitis, the appendix is non-compressible
b) Maximum diameter: a maximum diameter of greater than 6 mm is considered abnormal.
c) Wall thickness: a single wall thickness of 3 mm or more is considered abnormal.

d) Target sign appearance: - this is caused by a fluid-filled centre (hypoechoic centre), surrounded by a hyperechoic ring (mucosa/submucosa) which is surrounded by a hypoechic muscularis layer giving a target sign on axial imaging
e) Presence of an appendicolith (an echogenic focus with posterior acoustic shadowing).
f) Vascularity: peripheral appendiceal wall hyperaemia
g) Periappendicular fluid collection
h) Omental thickening & increased echogenicity- echogenic periappndicecal fat
i) Localised distension of bowel loops with reduced peristalsis – ilieus
j) Terminal mesenteric nodes – enlarged, more than 10 mm size with increased vascularity

EQUIPMENT SELECTION AND TECHNIQUE: Use of a high resolution probe (7-15MHZ) is essential. Beam steering or compounding can help to overcome anisotropy in linear structures such as tendons. Good color / power / Doppler capabilities. Be prepared to change frequency output of probe (or probes) to adequately assess both superficial and deeper structures. Used Toshiba Xario & Philips iU22 ultrasound systems.

ULTRASOUND CRITERIA TO DIAGNOSE APPENDICITIS: In order to demonstrate all the possible presentations of appendicitis it is important that the entire appendix is visualized

- when the outer diameter of the appendix measures greater than 6 mm
- Echogenic inflammatory periappendiceal fat change
- The wall thickness can measure almost 3 mm or greater
- Progressed appendicitis can demonstrate a gangrenous appendix. The lumen distends tremendously sometime upwards to 2 cm and is not compressible. An appendicolith may be present which will cast an acoustic shadow.
- An appendicolith may be present which will cast an acoustic shadow
- Or a perforated appendix is demonstrated when the appendicular wall has ruptured producing fluid or a newly formed abscess. The appearance is hyperechoic with an echo-poor abscess surrounding the appendix. There may be a reflective omentum around the appendix, a thickened bowel, and enlarged lymph nodes. Asymmetrical wall thickening may indicate perforation.
- free fluid in the periappendiceal region

Ultrasonographic findings: Major ultrasonographic findings in acute appendicitis in the RLQ include the following:

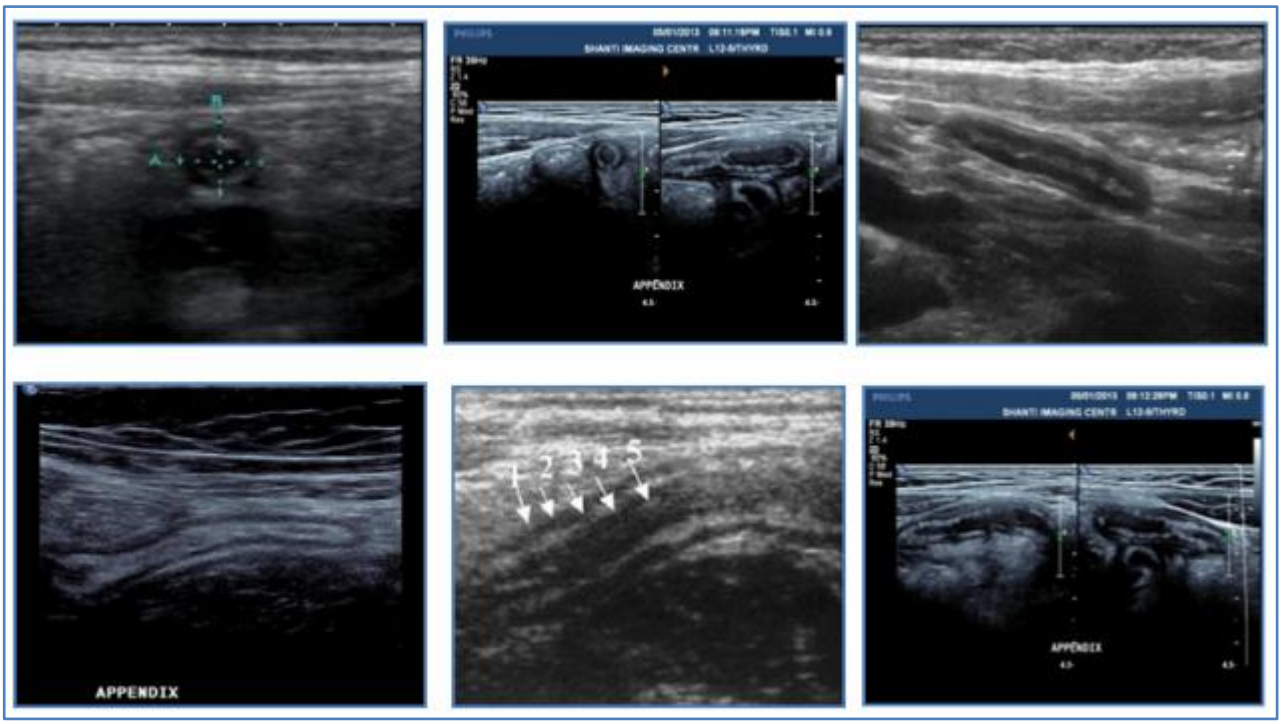
- An aperistaltic, non-compressible, blind-ended, sausage-shaped structure that arises from the base of the cecum
- Distinct appendiceal wall layers
- An outer diameter greater than 6 mm
- A target appearance
- Appendicolith(s) (See the images below.)
- Periappendiceal fluid collection
- Echogenic, prominent pericecal fat

Normal appendix: A normal appendix is infrequently observed using gray-scale US, but this structure can be visualized as a blind-ended, tubular, compressible intestinal loop that is continuous with the cecum and has a diameter of less than 6 mm, particularly in thin patients.

COMMON PATHOLOGY: (click for link to pathology page with descriptions and images)

- Appendiciitis
- Mesenteric Adenitis
- Ovarian pathology
- Crohn's disease
- Diverticulitis
- Abscess

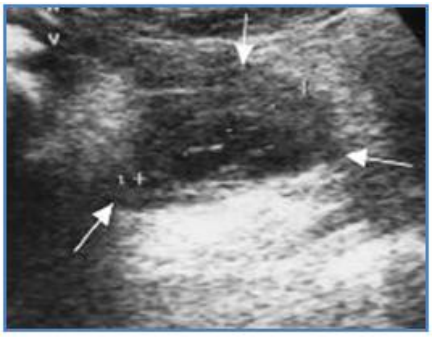
Suppurative appendicitis: The longitudinal ultrasonographic view demonstrates a non-perforated, inflamed appendix that is characterized by an aperistaltic, non-compressible, blind-ended, tubular structure with a laminated wall that arises from the base of the cecum. When the inflammation is mild and visualization is optimal, 5 distinct appendiceal wall layers can be identified (see the image below).



Gangrenous appendicitis: Generalized or focal loss of the echogenic submucosal layer of the appendiceal wall, as well as the prominent, surrounding, echogenic fat, is consistent with gangrenous appendicitis (see the images below).

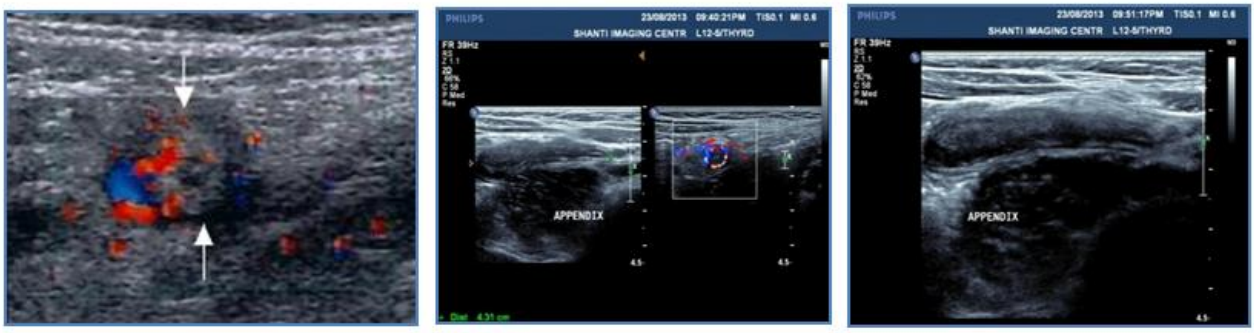
Perforated appendicitis: In the diagnosis of a perforated appendicitis, gray-scale ultrasound is also a valuable diagnostic tool, Irregularity of and damage to the contour of the appendix by the presence of periappendiceal fluid and hyperechoic, prominent pericecal fat are diagnostic of perforation Gas bubbles occur within a fluid collection in cases of perforation or as a result of gas-forming organisms. A localized perforation of the appendiceal tip may also demonstrate gas pockets in the perforation site.

Periappendiceal phlegmon and abscess: A phlegmon appears as a localized fluid collection, which is walled off by the adjacent greater omentum and small-bowel loops. An appendiceal abscess appears as a complex, hypoechoic mass adjacent to the cecum or appendix. In these patients, the inflamed appendix may not be visualized (see the image below)**.**



Color Doppler ultrasonographic findings: Color Doppler US is beneficial in the evaluation of inflammatory conditions of the intestinal tract, and according to most authors, this modality is a useful adjunct to conventional US in the assessment of acute appendicitis.

A normal appendix seldom shows findings of mild hyperemia on Doppler ultrasonographic examination. However, an inflamed appendix uniformly shows greater flow than a normal appendix, and circumferential color in the wall of the inflamed appendix (seen in the image below) as observed on color Doppler ultrasonographic images is a strong indicator of acute appendicitis.



Alternative disease: Ultrasonographic examination is also useful for diagnosing alternative pathology, such as a tubo-ovarian abscess, ovarian torsion, ovarian cyst, or mesenteric adenitis, especially in women of childbearing age. Establishment of an alternative diagnosis does not exclude appendicitis. However, it is a double benefit when appendicitis can be excluded by US and an alternative diagnosis is made. Step 1:

Limitations to Visualization: Several factors can make diagnosing acute appendicitis with ultrasound challenging. Technical aspects affecting the ability of the sonographer to achieve adequate compression of the RLQ such as obesity, severe pain or abdominal guarding, excessive bowel gas, and an uncooperative patient can all affect the accuracy of the ultrasound. Operator experience can also affect the study result.

A retrocecal appendix is often difficult to identify as high-frequency transducers may fail to appropriately visualize deep structures. One can aid in the visualization of the retrocecal appendix by either scanning via a lateral flank approach or by turning the patient to the left lateral decubitus position in order to obtain views posterior to the cecum The left lateral decubitus technique may also be helpful in pregnant patients with suspected appendicitis, with this position shifting the uterus away from the RLQ and allowing easier visualization of the appendix.[31] Additionally, one author promotes using a 500-1000 cc saline enema for non-visualization of the appendix in children and cites improved visualization rates with this method in the pelvic, retrocecal, and retroileal position

A perforated appendix can result in an inconclusive or false negative study. This is likely due to difficulty with adequate compression of the abdomen due to guarding or dilatation of bowel loops as a result of peritonitis and/or the failure to recognize the decompressed appendix after pus evacuation.

DIFFERENTIAL DIAGNOSES VISIBLE ON ULTRASOUND

- Ovarian abnormality
- Mesenteric adenitis
- Renal calculi

COMMON PATHOLOGY

- Appendiciitis
- Mesenteric Adenitis
- Ovarian pathology
- Crohn's disease
- Diverticulitis
- Abscess

Pitfalls: The accuracy of ultrasonography is operator dependent and requires both skill and experience. The appendiceal diameter should be measured from outer wall to outer wall to obtain an accurate measurement. Additionally, it is important to visualize the entire length of the appendix, including the distal tip, to confirm that it is blind-ending, as the most common cause of misdiagnosed appendicitis by ultrasonography is mistaking the terminal ileum for an inflamed appendix. Visualization of the appendiceal tip is also important so that early appendiceal inflammation, which can often be confined to the distal tip, is not missed. Finally, other disease entities such as colonic diverticulitis, Crohn's disease, pelvic inflammatory disease, epiploic appendagitis, and terminal ileitis can result in false-positive scans.

CONCLUSION: Bedside ultrasound is helpful in patients with suspected appendicitis to confirm the diagnosis. Further imaging may be warranted if the ultrasound is equivocal.

RESULTS: The ultrasound-derived diagnosis of appendicitis had a sensitivity of 85.5%, a specificity of 84.4%, a positive predictive value of 88.3%, a negative predictive value of 80.1%, and an overall accuracy of 85.0%. The surgeon's clinical impression at the time of admission had a sensitivity of 62.9%, a specificity of 82.2%, a positive predictive value of 82.9%, a negative predictive value of 61.7%, and an overall accuracy of 71.2%.

CONCLUSION: The overall accuracy of ultrasonography in the diagnosis of appendicitis was statistically superior to that of the surgeon's clinical impression ($P < .0001$). However, 24% of the patients with normal ultrasound findings were ultimately found to have appendicitis at operation, emphasizing the point that ultrasonography cannot be relied on to the exclusion of the surgeon's careful and repeated evaluation.

REFERENCES:

1. Puylaert JB. Acute appendicitis: US evaluation using graded compression. Radiology 1986; 158(2): 355-60.

2. Balthazar EJ, Birnbaum BA, Yee J, et al. Acute appendicitis: CT and US correlation in 100 patients. Radiology 1994; 190(1): 31-5.
3. Brenner DJ, Hall EJ. Computed tomography - an increasing source of radiation exposure. N. Engl. J. Med. 2007; 357(22): 2277-84.
4. Garcia Peña BM, Mandl KD, Kraus SJ, et al. Ultrasonography and limited computed tomography in the diagnosis and management of appendicitis in children. JAMA 199915; 282: 1041-6.
5. Ramarajan N, Krishnamoorthi R, Barth R, et al. An interdisciplinary initiative to reduce radiation exposure: Evaluation of appendicitis in a pediatric emergency department with clinical assessment supported by a staged ultrasound and computed tomography pathway. Acad. Emerg. Med. 2009; 16(11): 1258-65.
6. Poortman P, Oostvogel HJ, Bosma E, et al. Improving diagnosis of acute appendicitis: Results of a diagnostic pathway with standard use of ultrasonography followed by selective use of CT. J. Am. Coll. Surg. 2009; 208(3): 434-41.
7. Doria AS, Moineddin R, Kellenberger CJ, et al. US or CT for diagnosis of appendicitis in children and adults? A meta-analysis. Radiology 2006; 241(1): 83-94.
8. Abo A, Shannon M, Taylor G, Bachur R. The influence of body mass index on the accuracy of ultrasound and computed tomography in diagnosing appendicitis in children. Pediatr. emerg. Care 2011; 27(8): 731-6.
9. Josephson T, Styrud J, Eriksson S. Ultrasonography in acute appendicitis: Body mass index as selection factor for US examination. Acta. Radiol. 2000; 41(5): 486-8.
10. Hörmann M, Scharitzer M, Stadler A, et al. Ultrasound of the appendix in children: Is the child too obese? Eur. Radiol. 2003; 13(6): 1428-31.
11. Grayson DE, Wettlaufer JR, Dalrymple NC, Keesling CA. Appendiceal CT in pediatric patients: Relationship of visualization to amount of peritoneal fat. Am. J. Roentgenol. 2001; 176(2): 497-500.
12. Pohl D, Golub R, Schwartz GE, et al. Appendiceal ultrasonography performed by nonradiologists: Does it help in the diagnostic process? J. Ultrasound Med. 1998; 17(4): 217-21.
13. Fox JC, Solley M, Anderson CL, et al. Prospective evaluation of emergency physician performed bedside ultrasound to detect acute appendicitis. Eur. J. Emerg. Med. 2008; 15(2): 80-5.
14. Pohl D, Golub R, Schwartz GE, et al. Appendiceal ultrasonography performed by nonradiologists: Does it help in the diagnostic process? J. Ultrasound Med. 1998; 17(4): 217-21.
15. Gaitini D, Beck-Razi N, Mor-Yosef D, et al. Diagnosing acute appendicitis in adults: Accuracy of color Doppler sonography and MDCT compared with surgery and clinical follow-up. Am. J. Roentgenol. 2008; 190(5): 1300-6.
16. Lehnert BE, Gross JA, Linnau KF, et al. Utility of ultrasound for evaluating the appendix during the second and third trimester of pregnancy. Emerg. Radiol. 2012 Feb. 28 (Epub ahead of print).

17. Israel GM, Malguria N, McCarthy S, et al. MRI vs. ultrasound for suspected appendicitis during pregnancy. J. Magn. Reson. Imaging 2008; 28(2): 428-33.
18. Sivit CJ, Applegate KE, Stallion A, et al. imaging evaluation of suspected appendicitis in a pediatric population: Effectiveness of sonography versus CT. Am. J. Roentgenol. 2000; 175(4): 977-80.
19. Schwerk WB, Wichtrup B, Rothmund M, Rüschoff J. Ultrasonography in the diagnosis of acute appendicitis: A prospective study. Gastroenterology 1989; 97(3): 630-9.
20. Stone MB, Chao J. Emergency ultrasound diagnosis of acute appendicitis. Acad. Emerg. Med. 2010; 17(1): E5.
21. Lee JH. Sonography of acute appendicitis. Semin. Ultrasound CT MR. 2003; 24(2): 83-90.
22. Brown MA. Imaging acute appendicitis. Semin. Ultrasound CT MR. 2008; 29: 293-307.
23. Taylor GA. Suspected appendicitis in children: In search of the single best diagnostic test. Radiology 2004; 231: 293-5.
24. Pacharn P, Ying J, Linam LE, et al. Sonography in the evaluation of acute appendicitis: Are negative sonographic findings good enough? J. Ultrasound Med. 2010; 29: 1749-55.
25. Cole MA, Maldonado N. Evidence-based management of suspected appendicitis in the emergency department. Emerg. Med. Pract. 2011; 13(10): 1-29.
26. Ang A, Chong NK, Daneman A. Pediatric appendicitis in "real-time": The value of sonography in diagnosis and treatment. Pediatr. Emerg. Care 2001; 17(5): 334-40.
27. Ma OJ, Mateer J, Blavais M. Emergency Ultrasound. 2nd ed. 2007. McGraw Hill.
28. Lee JH, Jeong YK, Hwang JC, et al. Graded compression sonography with adjuvant use of a posterior manual compression technique in the sonographic diagnosis of acute appendicitis. Am. J. Roentgenol. 2002; 178(4): 863-8.

AUTHORS:

1. P. S. Mishrikotkar
2. R. J. Totla
3. Haseeb
4. Jyoti Rai
5. Gaurav Sharma
6. Sarvesh Patil

PARTICULARS OF CONTRIBUTORS:

1. Professor, Department of Radiology, MGM Medical College, Aurangabad.
2. Associate Professor, Department of Surgery, MGM Medical College, Aurangabad.
3. Paediatrician, Department of Paediatrics, MGM Medical College, Aurangabad.
4. Shanti Imaging Centre.
5. Senior Resident, Department of Radiology, MGM Medical College.
6. Senior Resident, Department of Radiology, MGM Medical College.

NAME ADDRESS EMAIL ID OF THE CORRESPONDING AUTHOR:

Dr. P. S. Mishrikotkar,
21/22, Row House Complex,
Seven Hills Colony,
Aurangabad – 431005.
E-mail: mishrikotkarss29@rediffmail.com

Date of Submission: 22/05/2014.
Date of Peer Review: 23/05/2014.
Date of Acceptance: 22/09/2014.
Date of Publishing: 07/10/2014.