SYSTEMATIC / NARRATIVE REVIEW ARTICLE

# Role of clinical scoring system and imaging in acute appendicitis in adults: a review of literature

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## ABSTRACT

**Introduction: Ultrasound is widely available, easy-to-use and less expensive than most other imaging methods. It is widely used as a non-invasive method to diagnose acute appendicitis; however, its efficiency still remains questionable, especially when compared to costlier and invasive methods such as computed tomography.**

**Methods: An exploratory review of past literatures on the usage of ultrasound technique in the diagnosis of acute appendicitis in adult patients, and the role of other imaging techniques were undertaken for the study.**

**Results: The gold standard for the diagnosis of acute appendicitis still remains a histopathological confirmation after appendectomy. The study further shows imaging has high diagnostic accuracy in the diagnosis of acute appendicitis with low rate of negative appendectomy (<10%). Multiple reasons are identified, including the introduction of computed tomography imaging especially in those patients where ultrasound was unequivocal, more education on imaging which leads to better operator skill or improved performances of machines.**

**Conclusion: Imaging undoubtedly plays an important role in the diagnosis of acute appendicitis with ultrasound remaining the first-line method in patients referred with clinically suspected acute appendicitis. Nevertheless, those with borderline ultrasound findings or unable to visualize appendix on ultrasound with highly suspicious sign and symptoms were offered other imaging modalities such as CT scan.**

**Recommendation: It is recommended that the managing team balance the risk of radiation exposure, risk of delay in urgent operation and risk of perforation prior to a decision.**

**KEY WORDS:**
*Acute appendicitis, ultrasound in appendicitis, Alvarado score, negative appendectomy rate*

## INTRODUCTION

Acute appendicitis (AA) is the most common abdominal surgical emergency in the world. Reich and colleagues reported that the lifetime prevalence of acute appendicitis was approximately 7% overall with a lifetime risk of 8.6 percent in male and 6.9 percent in female.[1] Prevalence of AA peak in the second and third decades of life.[2,3,4,5] Using traditional diagnostic methods based on patient history and physical examination, the accuracy rate for detecting acute appendicitis is 78% to 92% for men and 58% to 92% for women.6 In recent years, with the development and evolution of management protocols involving ultrasound and then CT scan if ultrasound is unequivocal, the rate of negative appendectomy has lowered significantly. Parks and Schroeppel, had estimated the rate at to be at 4.9% in patients with imaging, compared with 9.8% in patients without imaging.[6]

## AIM OF STUDY

The study intends to survey literatures on the role of clinical scoring system and trends in imaging and its accuracy in diagnosing acute appendicitis in adults.

## METHODOLOGY

*Source of Data*

A survey of literature review was undertaken to study the role of clinical scoring system and trends in imaging and its accuracy in diagnosing acute appendicitis in adults. Samples of published articles in reputable medical journals were used for the purpose of the review. PubMed and Google Scholar were the primary source of articles.

*Search Strategy*

The search was aided using the following key phrases: "diagnosis of appendicitis", "imaging AND appendicitis", "ultrasound AND appendicitis" and "Alvarado score".

*Inclusion criteria*

Prospective and retrospective studies were selected for this literature review if they met the following criteria:

- Included at least 50 subjects.
- Reported relevant clinical outcomes, such as sensitivity, specificity, positive predictive value, negative predictive value and negative appendectomy rate.
- Examined adult's population (age >12)
- Contained imaging test results and histological results, and used histological findings from surgery as the gold standard.

*Exclusion criteria*

Thirty-one studies were eliminated from the initial number as they did not meet the search criteria.

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## RESULTS

*Search results*

By using search strategy, inclusion and exclusion criteria as identified above and with the use of words full-articles or PDF articles only, articles were found as full length articles and not merely abstract. Publications from Google Scholar and PubMed, MEDLINE and EMBASE were reviewed. A few articles were given preferences based on its relevance and accuracy to the current study.

*Empirical Studies*

The sequence of central abdominal pain followed by migration to right iliac fossa was first described by Murphy, but these may only be present in half of the patients with suspicion of acute appendicitis. To improve diagnostic accuracy, in recent years, laboratory investigations have been introduced. The most well-known and widely used is the Alvarado scoring system. Imaging investigations are commonly requested depending on individual centres practises to confirm or rule out the diagnosis of acute appendicitis.

Imaging techniques especially in the form of abdominal ultrasound have augmented major importance in recent years, as awareness and comprehension of radiation exposure and its associated risk, easy availability and cost effectiveness became progressively paramount aspect of modern imaging techniques.This serves to keep both the perforated appendicitis rate and negative appendicectomy rate low. The high mortality and morbidity associated with perforation has been used to validate high rates of negative appendicectomy, quoted as between 20% and 25%.[7] A study indicated that the surgical community generally take that around 15% of appendectomies will accrue a normal non inflamed appendix.[8]

Lumen of the appendix is blocked commonly due to lymph node hyperplasia, parasites or appendicolith.[9,10] The clinical diagnosis is usually made on the grounds of the recollection of symptoms, positive physical examination signs of appendicitis such as rebound tenderness, Blumberg's, Rovsing's, Obturator, and Psoas sign and elevated inflammatory markers such as elevated C-reactive protein (CRP) and total white blood cell count. A raised CRP is related to the severity of the disease and is a possible benchmark for perforation while a raised white cell count is more sensitive for distinguishing early appendicitis.[11]

Prior to the introduction of imaging modalities, the rate of negative appendectomy was significantly higher.

*Clinical Scoring System and Issues*

The clinical evaluation of acute abdominal pain requires systematic examination of the presenting signs and symptoms. The Alvarado score (AS), also known as MANTRELS scores, a combined clinical and laboratory point scale that quantifies the potential likelihood of appendicitis.[15]

AS of 3 or less is in concordance with a low risk of appendicitis.[16] Alvarado's original work was published in 1988 and is established on retrospective data analysis of 305 patients presenting with abdominal pain suggestive of acute appendicitis. The study pinpointed eight predictive factors of diagnostic value in acute appendicitis and designated each factor a value of 1 or 2 based on their diagnostic weight.

A score of 1 was given for each of the ensuing criteria: elevated temperature >37.3°C, rebound tenderness, migration of pain to right lower quadrant (RLQ), anorexia, nausea or vomiting, and leukocyte left shift. A score of 2 was given for RLQ tenderness and leucocytosis>10,000.T h e probability of appendicitis and distinct management recommendations are suggested based on the full score. A score of 5 or 6 is "compatible" with the diagnosis of acute appendicitis and advocates the clinician observe or serially examine the patient. A score of 7 or 8 is "probable" appendicitis and a score of 9 or 10 is "very probable" appendicitis and recommends surgical or operative intervention.[17]

Subsequent affirmation studies on Alvarado score mostly surpassed the original study's findings and granted major foothold for consideration of other observation in clinical practise. In a meta-analysis by Ohle et al., conducted in 2011, a review of 29 studies revealed that for a cut-off of 5 (criteria to observe/ admit) there was a sensitivity of 99% and specificity of 43%. At a cut-off of 7 (criteria to advance to surgery) sensitivity was 82% and specificity was 81%. Based on this result, the authors argue that using a cut-off score of 5 or lower yield a good "ruling out" score, while a cut-off of 7 is inadequate to provide a "ruling in" score.[18]

A retrospective study by Jones et al., in 2015 described 119 consecutive adults for whom appendiceal sonography was performed as the initial imaging investigation for suspected appendicitis, who subsequently underwent CT scan within 48 hours when the appendix was not seen on an otherwise unremarkable sonography, consummated that adult patients with AS of 3 or lower and non-visualized appendixes on otherwise regular ultrasound are not likely to benefit from CT in either the diagnosis of appendicitis or clinically important alternative diagnoses. None (0.0%, 0/49) with Alvarado scores 3 or lower had appendicitis, in comparison to 17.1% (12/70) of patients with Alvarado scores 4 or higher. The rate of appendiceal perforation, along with significant surrogate CT findings, did not differ fundamentally. Patients with higher Alvarado scores have better chance of appendix visualization at ultrasound. Although these researchers differ on the exact cut-off bench mark, there is a general agreement that an increasing and higher score implies the patient has higher probability of appendicitis.

*Imaging Modalities*

Three imaging modalities are frequently used as an adjunct to diagnose acute appendicitis: ultrasound (US), computed tomography (CT), and magnetic resonance imaging (MRI). Transabdominal ultrasound is the first-line imaging test in majority of cases, except for the paediatrics and obstetric population, whose radiation exposure and risk is of particular interest and concern. Abdominal CT is superior to US on patients with atypical clinical presentation of appendicitis and suspected perforation. A low dosage plain non contrasted CT (NECT) is as good as standard dosage contrasted CT to identify the five signs of acute appendicitis

**Table I: Negative appendectomy rate published by various studies**

| Author(s) | Study Year | Modalities discussed | Age (Years) | Population size | Country | Negative size appendectomy rate (%) |
|---|---|---|---|---|---|---|
| Hartwig Korner et al.[12] | 1997 | none | 13-40<br>41-65 | 1486 | Hong Kong | 24<br>18 |
| E. P. Johansson et al. [13] | 2007 | Ultrasound and CT scan | 18-94 | 305 | Sweden | 9 |
| Pieter Poortman et al.[14] | 2008 | Ultrasound and CT scan | 18-80 | 151 | United States of America | 8 |

(wall thickening of appendix more than 2 mm, diameter more than 6 mm, peri-appendicitis, abscess, and appendicolith).

➢ **Ultrasound**

Transabdominal ultrasound is the most widely available and utilised imaging modality in cases of suspected appendicitis and is essentially a component of the clinical examination.19 Using ultrasound has many advantages, for example it is relatively inexpensive, usually readily available, involves minimal or no patient preparation, is non-invasive, does not involve contrast administration, can be repeated and does not cause too much of discomfort to the patient. There are no absolute contraindications, other than patient refusal for the scan. However, scan findings can be affected and limited by certain patient factors such as overlying bowel gas, peritonitis with guarding, or adiposity causing the appendix region to be insufficiently assessed. Atypical position of the appendix, even though inflamed, will be difficult to pick upon ultrasound and would be readily interpreted as false negative.[20]

The sensitivity and specificity of ultrasound (US) are highly variable and depends on various factors. US in the case of suspected appendicitis have a sensitivity and specificity of 97.3% and 91% respectively.[21]

First, the examiner should begin scanning the abdominal region with a convex probe (2–5MHz). Next, perform targeted imaging of the vermiform appendix using a low frequency and high resolution linear probe (7.5 – 14 MHz). The examiner usually asks the patient to point with one finger the point of maximal tenderness, and using patient's pain as a guide, look for the ileocecal pole. Most commonly, the appendix is found in the retrocecal position. The non-inflamed appendix has diameter not more than 6mm and the appendix can be compressed (visualised on ultrasound) when the examiner applies pressure via the ultrasound probe.[22,23] The benchmark of an inflamed appendix is visualization of the abnormal appendix directly. The classic sign on ultrasound is a structure comprised of multiple alternating concentric layers, also known as target sign. The appendix would appear dilated (diameter more than 6mm) with its wall hypoechoic and greater than 2mm thickness. The normal appendicular wall layering is absent especially in the presence of necrosis.[24] The commonest cause of inflammation of the appendix is due to appendicolith, this demonstrates characteristic posterior acoustic shadowing on ultrasound. In cases where the examiner is unable to visualise the appendix, the next step should be to look for secondary sonographic signs of acute appendicitis. These include peritoneal free fluid especially in the right iliac fossa, increased echogenicity of the adjacent tissue due to infiltration of neighbouring adipose tissue, caecal or terminal ileum wall thickening, reactive and enlarged abdominal or pelvic lymph nodes. In a perforated appendix, there is usually a break of continuity of the appendix contour.

The efficiency of CT did not diverge significantly according to BMI. He summarized that role of ultrasound in overweight patients with clinical suspicion of acute appendicitis is doubtful because of high rate of non-conclusive findings. Hence, CT scans should be preferred and offered to overweight patient if other clinical parameters are non-conclusive.

➢ **Computed Tomography**

There are two schools of thoughts on the utilization of CT scan to diagnose acute appendicitis: one in favour of its regular use due to the low incidence of negative appendectomies, and the other not in favour of its routine use due to the higher cost involved, delay in operative intervention and the risk of radiation exposure. If clinical history and systemic examination, lab parameters and ultrasound is unable to come to a diagnosis of appendicitis and pregnancy is ruled out, CT scan of the abdomen should be offered especially in case of unequivocal ultrasound findings and patients presenting with atypical signs and symptoms of appendicitis or suspected perforation. Atypical signs are detected in about 1/3 of all patients.[25]

The radiologist evaluating the CT images should assess for primary CT signs of appendicitis.[26,27,28] These are:

1. Appendiceal enlargement with diameter more than 6 mm
2. Appendiceal wall thickening more than 2 mm
3. Inflammatory compression of the adjacent fat tissue
4. Heterogenous collection or abscess formation
5. Presence of appendicolith.

If the first three criteria above are all present, this is highly suggestive of a non-perforated acute appendicitis. In a contrasted CT abdomen, the portal venous phase in particular is excellent to diagnose an acutely inflamed appendicitis. This is because the five signs mentioned above are best assessed for in this phase. Furthermore, contrasted CT scan of the abdomen can display an appendix with thickening of its wall and ring like contrast enhancement that is classic for the diagnosis. Another superiority of intravenous contrast utilisation is the visualization of complications. In perforation of an appendix, an encased, contrast enhanced collection or abscess in the right iliac fossa is better assessed compared to plain CT scan. There are few

recognized contraindications for contrast agent administration via intravenous access. These are for instance known allergy to contrast agent, renal impairment or hyperthyroidism due to the risk of thyroid storm. Oral or rectal contrast agent administration on top of contrast agent application is considered not indicated by some authors. This is because it has not proven to increase the sensitivity or specificity.[29,30,31]

Coursey et al., analysed the employment of CT scan prior to operation in patients with suspected appendicitis and the consequence on negative appendectomy rate. The frequency of preoperative CT scan in a 10-year period elevated markedly from 18.5% to 93.2% leading to significant drop of rate of negative appendectomies from 16.7% to 8.7%.[32] Several studies compared the accuracy of low dosage CT and standard CT in diagnosing suspected appendicitis.[33,34,35] They are in favour of low dosage CT, because it is deemed as good as contrasted CT for diagnosing appendicitis. Kim et al., analysed the negative appendectomy rates in 890 patients subjected to standard and low dosage CT in a randomized prospective study. The patients were separated into two cohorts. In the first cohort, 438 patients were subjected to low-dose CT versus the second cohort, in which 441 patients were subjected to standard CT. Intravenously contrast agent was given to every patient. Acute appendicitis was histopathologically confirmed in 37.9% of the patients in the first cohort and in 40.8% in second cohort. The negative appendectomy rate after low dosage CT scan was 3.5% (6/172 patients) versus 3.2% (6/186 patients) after standard CT.

Seo et al, demonstrated that low dosage CT without contrast agent administration is indistinguishable to standard CT. A total of 207 adults suspected of acute appendicitis was examined in this retrospective study. 78 patients had histopathologically confirmed acute appendicitis. Two radiologists who were blinded reported the images. The sensitivity and specificity for low dosage CT without contrast were 98.7% and 95.3%, respectively, and for standard CT with contrast agent, 100 % and 93% respectively. When the initial ultrasound is non-conclusive, CT scan can be employed as an adjunct second line imaging technique.

➢ **Magnetic Resonance Imaging**

The subgroup in which MRI could be indicated is those with special radiation protection requirements such as paediatric age group, women of childbearing age and pregnant women. Early diagnosis and management of acute appendicitis during pregnancy curbs the complications that could risk the life of the mother and her unborn child. Due to factors such as long examination duration, increased cost compared to other examinations, and finite availability, MRI abdomen is not the front runner in the case of clinical suspicion of acute appendicitis. There are a few known contraindications for a MRI scan, these are: pacemaker, claustrophobic patient, metal implants or surgical vascular clips.

Plain non-contrasted MRI abdomen usually provides excellent visualization of the vermiform appendix. This is mainly due to the high soft tissue contrast.[36] Furthermore, some authors advocate for an additional alternative sagittal sequences to aid in localizing the appendix.[37] Most of the times, transverse and coronal sequences is sufficient to assess the appendix.[38,39] T1-weighted sequences are used to assess for hypointense appendiceal wall while T2-weighted sequences are used to assess hyperintense appendiceal wall. This allows for best characterization of both the appendix and peritoneal fat. T2-weighted images also permits excellent assessment of the intramural oedema and secondary inflammatory changes surrounding the appendix.

Due to the limited clinical data on contrast agent utilisation in pregnancy, the doctor must weigh the risk and benefit carefully before making a decision. There are a few well described MR signs of acute appendicitis, these are:

- Enlarged appendix with its diameter more than 7 mm
- Oedematous compression of the surrounding fat
- Limited diffusion in the appendix wall
- Formation of abscess secondary to appendix perforation

The first three signs mentioned above are most specific. The possibility of having acute appendicitis is 88 % if one of these is detected, increases to 94 % if two signs are detected, and 96 % if all of the three imaging findings are available.[40] The sensitivity and specificity of contrasted MRI for the diagnosis of acute appendicitis are between 90% and 100% as in the case of CT.

Incesu analysed and compared the accuracy, superiority and constraint of MR imaging and ultrasound in identifying appendicitis. They incorporated 60 patients suspected of having appendicitis who was subjected to both abdominal ultrasound and MR imaging. The initial MR imaging and ultrasound reports were correlated with the intra-operative and histopathological findings. 34 out of 60 patients were confirmed to have appendicitis. The accuracy and negative predictive values for MR and ultrasound was compared and constructed to be statistically significant, suggesting that MR imaging is better compared to ultrasound in detecting appendicitis. The author suggests that MR imaging can be considered in a non-conclusive ultrasound in patients with suspected acute appendicitis.

## DISCUSSION

The well-known and widely used clinical scoring system for acute appendicitis is the Alvarado scoring system. Patients with higher scores have higher risk of appendicitis. Ultrasound (US), computed tomography (CT), and magnetic resonance imaging (MRI) are the three imaging modalities frequently used as an adjunct to diagnose acute appendicitis.

Transabdominal ultrasound is the first-line imaging test in majority of cases. Ultrasound is relatively inexpensive, usually readily available, involves minimal or no patient preparation, is non-invasive, does not involve contrast administration, can be repeated and does not cause too much of discomfort to the patient. Patients with higher Alvarado scores have better chance of appendix visualization at ultrasound. However, atypical position of the appendix, even though inflamed, will be difficult to pick upon ultrasound and would be readily interpreted as false negative.

On the other hand, abdominal CT is superior to US on patients with atypical clinical presentation of appendicitis and suspected perforation. CT scan was more useful than US in overweight patients. Hence, CT scans should be preferred and offered to overweight patient if other clinical parameters are non-conclusive.

MRI is preferred in those with special radiation protection requirements such as paediatric age group, women of childbearing age and pregnant women. MRI abdomen is not the first choice in the case of clinical suspicion of acute appendicitis due to factors such as long examination duration, increased cost compared to other examinations, and finite availability,. There are a few known contraindications for a MRI scan, these are: pacemaker, claustrophobic patient, metal implants or surgical vascular clips. MRI is better compared to ultrasound in detecting appendicitis and can be considered in a non-conclusive ultrasound in patients with suspected acute appendicitis. They concluded that a non-contrasted MRI is beneficial as a quick screening before proceeding with appendectomy. MRI also has high sensitivity, specificity and accuracy in detecting other pelvic abnormalities such as abscess formation, perforated diverticulitis, cystic ovarian lesions or inflammatory bowel disease. It has a role in preventing unwarranted surgeries.

## CONCLUSION

To summarize, in assessment of abdominal pain in patients presenting to hospital, all imaging modalities plays an important role. Alvarado score is a reliable clinical scoring system and can be used as an adjunct to clinical history and examination. Higher score indicates higher risk of having acute appendicitis. A multidisciplinary and multimodality approach is essential to increase accuracy of diagnosis and reduce complications or subjecting patients to unnecessary surgery. The authors advocate for the application of an ultrasound-first protocol in suspected cases of acute appendicitis in adults.

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