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A review of ultrasound for the diagnosis of acute appendicitis in adults

Vijay Pather[1,*], Preet Gosal[1]

[1]Department of General Surgery, Nepean Hospital, Kingswood, NSW, Australia.

Abstract

Acute appendicitis is one of the most common surgical emergencies globally, with a lifetime incidence of 8.6% in men and 6.7% in women. While acute appendicitis should be managed promptly to reduce the morbidity associated with perforated appendicitis, morbidity from negative appendicectomy is similar to morbidity from uncomplicated appendicitis. Computer tomography is widely used to aid in the diagnosis of acute appendicitis, however, is costly, often has a slow turn around time, and is associated with exposure to ionising radiation. In contrast, ultrasound is cheap, widely available, requires minimal patient preparation, and does not require exposure to ionising radiation. Ultrasonography is becoming increasingly used for adult patients in emergency settings. The literature has estimated the sensitivity of ultrasound for acute appendicitis in adult patients as between 39-96.4%. The sensitivity and specificity of ultrasound for the diagnosis of acute appendicitis is significantly increased when the appendix is visualised. In cases of a non visualised appendix, indirect ultrasound signs can improve the sensitivity to 93.9% and specificity to 85.7%. The variation in sensitivity and specificity for ultrasound in the diagnosis of acute appendicitis in adults may be due to multiple factors. Ultrasonographer experience, a retrocaecal appendix and obesity have all been described. Given the availability, cost and potential to reduce the rate of negative appendicectomy, ultrasound should be considered as the first line imaging modality for adult patients presenting with suspected AA.

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Corresponding author:

Vijay Pather. B.Pharm, MD, MS, Department of General Surgery, Nepean Hospital, Kingswood, NSW, Australia.

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Introduction

Acute appendicitis (AA) is a surgical condition caused by acute inflammation of the vermiform appendix. It is considered to be one of the most common surgical emergencies globally [1]. AA is most commonly managed with surgical resection of the appendix. Appendicectomy is associated with morbidity and in rare cases, mortality. Because of this, it is imperative to reduce the rate of negative appendicectomy in patients presenting to hospital with suspected AA. While historically AA was considered a clinical diagnosis in which diagnostic imaging was not indicated, there remains a lack of consensus on what imaging modality should be used in adult patients who present with equivocal findings. The diagnostic accuracy of ultrasound for AA in adults has been widely discussed in

the literature, however, literature is often limited to single centre studies with sensitivity and specificity varying widely. This review aims to evaluate the contemporary literature to determine the indications, diagnostic accuracy, and pitfalls of ultrasonography in suspected AA.

Review

AA is one of the most common surgical emergencies globally. AA has a lifetime incidence of 8.6% in men and 6.7% in women, with a peak incidence between the second and third decade of life [2]. The classic presentation of AA is characterised by migratory abdominal pain to the right iliac fossa, associated with localised peritonism. The classical presentation has been estimated to occur in between 50 to 60% of patients, with atypical presentations occurring commonly due to a retrocaecal location of the appendix, or due to patient factors such as pregnancy or obesity [3]. Appendicectomy following clinical diagnosis is associated with a 20% negative appendicectomy rate [4]. While prompt diagnosis and management of AA is important to reduce the morbidity associated with perforated appendicitis, negative appendicectomy has been associated with similar morbidity as compared to appendicectomy in patients with uncomplicated AA [5]. Given the morbidity associated with negative appendicectomy, imaging modalities should be considered to increase the diagnostic accuracy in patient presenting with suspected AA.

Diagnostic imaging should be strongly considered in undifferentiated abdominal pain where AA is suspected. Computer tomography (CT) is widely used and is considered by many to be the gold standard in the diagnosis of AA. Sensitivity and specificity for CT in evaluation of AA is between 72 -97% and 91-99% respectively [6]. CT has a positive predictive value (PPV) of 92-98% and a negative predictive value (NPV) of 95-100% [6]. While the respective PPV and NPV makes CT an ideal imaging modality, its use is associated with exposure to ionising radiation, with an estimated 0.7% of neoplasms in adults being caused by CT radiation exposure [7]. As compared to CT, ultrasound has multiple benefits including its lack of ionising radiation, minimal patient preparation, wide availability, fast turn around time, portability and cost [8, 9]. A review by Mostbeck et al., argues that while ultrasound should be considered the first line imaging modality in all patients for AA, CT should be considered as a first line investigation for adults in departments which lack ultrasound experienced clinicians, particularly overnight [10].

Ultrasonography is becoming an increasingly used modality in emergency settings due to its simplicity and wide availability. Sensitivity for ultrasound in the diagnosis of AA varies widely, quoted between 39-96.4% in the literature [11,12]. A meta analysis by Giljaca et al., determined a post test probability for positive and negatives ultrasound in AA as 92% and 55% respectively [12]. The disparity in sensitivity may be related to the relative experience of ultrasonographers, or ultrasound used in female patients [11, 12]. Despite this, a review by Alelyani et al., found that sensitivity and specificity rates based on sonographer experience were not statistically significant for the diagnosis of AA [13]. In a recent single centre study from Switzerland by Lehmann et al., 60.4% of adult participants with suspected AA had a visualised appendix on ultrasound, with an 89.6% sensitivity and 93.8% specificity in diagnosing AA amongst this group [14]. Another single centre study by Jha et al., demonstrated non-visualisation of the appendix in 67.3% of adult participants presenting with suspected AA [15]. In this study, 35.9% of participants with a non-visualised appendix underwent a CT scan, with 8.3% subsequently being diagnosed with AA on CT [15]. In cases of non visualisation of the appendix in adults, indirect ultrasound signs including pain with compression of the right iliac fossa, hypertrophy of adjacent peritoneal fat, and hypokinesia of bowel

loops may improve the diagnostic accuracy [16]. In a study by Kouamé et al., participants with a non -visualised appendix who had 3 indirect signs of AA on ultrasound had a sensitivity of 93.9% and specificity of 85.7% for the diagnosis of AA [16]. In this study, ultrasonography was performed by senior radiologists, with similar sensitivity and specificity as compared to previously published meta-analysis' where the appendix was visualised [6]. A meta-analysis published by Carroll et al., demonstrated a pooled sensitivity of 96% and specificity of 99% when surgeons performed ultrasonography for suspected AA as compared to ultrasonographers [17].

False negative diagnosis of AA is an inherent risk of non-visualisation of the appendix with ultrasonography. Literature evaluating the negative predictive value (NPV) in ultrasound for AA varies widely, with Sezer et al., determining a NPV of 33% [18], while Mallin et al., determined a NPV at 84.9% [19]. A low pre-test probability has been shown to increase the NPV up to 96.6% [3], whereas Jha et al., demonstrated a NPV of 100% when the appendix was visualised [15]. Operator factors, a retrocaecal appendix and obesity have been discussed in the literature as causes for the variation of sensitivity in detection of AA with ultrasound [3, 11], Piyarom et al., cite increased abdominal wall thickness as a more relevant factor in higher rates of false negative diagnosis [8]. In this study, difference in body mass index (BMI) was not statistically significant between true-positive and false-negative groups. Despite this, however, there was a trend towards higher rates of false-negative diagnosis with increasing BMI. In addition, Piyarom et al., found no statistical significance in appendix location, duration of symptoms, Alvarado score, or operator characteristics between the true positive and false negative groups [8].

Conclusion

Ultrasonography is a useful imaging modality to aid in the diagnosis of AA, with high sensitivity and specificity if utilised in the correct patient populations by experienced ultrasonographers. While CT has a higher NPV as compared to ultrasound, its cost, lack of availability and required exposure to ionising radiation limit its use as a first line imaging modality. Given the availability, cost, and significant potential to reduce the rate of negative appendicectomy, ultrasonography should be considered as the first line imaging modality for adult patients presenting with suspected AA.

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