

Is ultrasound a reliable diagnostic tool for acute appendicitis?

A single centre experience



Ann Ital Chir, 2017 88, 6: 557-561
pii: S0003469X1702752X
Epub Ahead of Print - November 14
free reading: www.annitalchir.com

Dimitrios Zosimas*, Panagis M Lykoudis**, Josh Burke***, Phoebe Leung***, Giuseppe Strano°, Veeranna Shatkar°°

*General Surgery, Queen's Hospital, Barking Havering and Redbridge University Hospitals NHS Trust, Essex, UK

**Honorary Research Associate, University College London, London, UK

***General Surgery, Queen's Hospital, Barking, Havering and Redbridge University Hospitals NHS Trust, Essex, UK

°General Surgery, Queen's Hospital, Barking Havering and Redbridge University Hospitals NHS Trust, Essex, UK

°°General Surgeon, Queen's Hospital, Barking Havering and Redbridge University Hospitals NHS Trust, Essex, UK

Is ultrasound a reliable diagnostic tool for acute appendicitis? A single centre experience

AIM: Aim of the present study is to evaluate the utility of US as a diagnostic method for acute appendicitis (AA) in a district general hospital, by use of accurate quality indices.

MATERIAL AND METHODS: The records of all patients who underwent an appendicectomy in a one year period in a single centre were reviewed. The patients who underwent a preoperative US scan were included in the study in accordance to specific criteria and the results were statistically compared to the final surgical histology.

RESULTS: 137 patients who underwent an US were included in the study, with 69 patients (23%) presenting a negative histology result. Overall, the US results correlated statistically significantly with the final histology results, with a specificity of 0.87, a sensitivity of 0.34 and an overall diagnostic accuracy of 0.51.

DISCUSSION: The results of the study are comparable with the reported literature, presenting high specificity but a relatively low sensitivity, although great variability exists in the literature. US seems useful in confirming rather than excluding AA.

CONCLUSION: In view of its advantages, the incorporation of ultrasonography into routine clinical practice when performed by an expert is recommended, but only in support of other diagnostic elements. The issue of low sensitivity should be further addressed.

KEY WORDS: Appendicectomy, Diagnostic accuracy, Histology

Introduction

Acute appendicitis (AA) is one of the most common surgical emergencies and appendicectomy remains among the most frequently performed emergency operations

worldwide¹. Since 1960, considerable efforts have been devoted to increase diagnostic accuracy and reduce negative appendectomy rates in patients with acute abdominal pain. Diagnosis of AA is still difficult, in particular among children, female adults, pregnant and elderly patients, perforation rates remain high and negative appendectomy rates are between 15% and 50%^{1,2}. A multitude of studies and various techniques have tried to address this issue, including radiological investigations. There is no accurate imaging method that diagnoses preoperatively appendicitis although computed tomography (CT) has become heavily involved in the evaluation of these patients. However, because of increasing concern

Pervenuto in Redazione Giugno 2017. Accettato per la pubblicazione Settembre 2017

Correspondence to: Dimitrios Zosimas, Hermitage Court, Woodford Road, E18 2EW, London, UK (e-mail: dizos@yahoo.com)

over the long-term malignancy risk related to ionizing radiation, the cost and other disadvantages, its routine use is debatable³. There is increasing interest in the use of ultrasound (US) as the primary imaging modality for confirming or ruling out the diagnosis of appendicitis. Introduced in 1986, graded compression US has well-established direct and indirect signs for diagnosing AA^{4,5} with advantages of avoidance of ionizing radiation, no need for contrast injections or sedation, less patient preparation, and ability to provide dynamic information through graded compression⁶. However, discrepancy is noted between the results of diagnostic preoperative US and histology results in patients undergoing appendectomy and indeed US is not accepted worldwide to rule out AA. US is well known to be operator-dependent and there is scant information about its performance across the different centres.

Often, results of large retrospective studies present only the negative appendectomy rate as a quality index of the diagnostic methods instead of indices such as the sensitivity, specificity, positive predictive value, or negative predictive value of each method⁷. Aim of the present study was to evaluate by use of accurate quality indices the utility and efficacy of US as diagnostic method for AA in the setting of a district general hospital.

Material and Method

The electronic records of all patients who underwent either open or laparoscopic appendectomy in a one year period in a single institution were reviewed retrospectively. The cases in which complicated ovarian cysts or other pathologies were identified during surgery or in which an appendectomy was performed during another primary procedure were excluded. The demographics of the patients were recorded. The results of the preoperative diagnostic US were studied and statistically examined along with the final histology. Criteria of positivity were a blind ending tubular structure with a non compressible lumen arising from the cecum, with increased blood flow in a thickened wall. US results when appendix was clearly not visualized were considered as negative. US results reported as inconclusive or unclear were excluded. Final histology was defined as negative when no evidence of appendicitis or other pathology was identified in the specimen and as positive when the specimen demonstrated evidence of appendicitis or other pathologic findings that could explain the symptoms that lead to surgery. Findings such as *Enterobius vermicularis*, meso-appendiceal abscess and carcinoid tumors of the appendix were accounted as positive histology. The diagnostic ultrasound system used was LOGIQ E9 (GE Healthcare Biosciences, Pittsburg, USA), with either a linear broad spectrum transducer (bandwidth 4-15 MHz) or a curvilinear broad spectrum transducer (bandwidth 1-6MHz).

DATA ANALYSIS

Correlations of categorical variables in 4-fold tables were assessed using Fisher's exact test (2-tailed). A p value of less than 0.05 was considered statistically significant. Statistical processing of data was conducted using SPSS v20 software (IBM Corporation, Chicago, IL, USA). Conduction of this work is in full compliance with local Ethical Regulations and Anonymization standards. Approval from local ethical committee was not required as this was not an interventional study, involving only retrospective analysis of clinical data associated with diagnostic and therapeutic techniques performed without any deviation from institute's local guidelines. The study analysed data retrospectively thus informed consent from the patients prior to their inclusion was not required according to local policy.

Results

A total of 311 patients underwent appendectomy in a one year's period in a single centre. Three hundred patients were analyzed of which 145 patients were male (48.3%) and 155 patients (51.7%) were female. Median age at time of surgery was 27 years (range 6-93). Two hundred and eleven patients (70.3%) underwent at least one type of diagnostic preoperative imaging. Sixty nine patients had a negative final histology (23%) while 231 patients (77%) had a positive final histology. After exclusion of five patients who had inconclusive or unclear results on the US, the total number of included patients who underwent US scan was 137 (Table I). US results were compared with final histology and it was revealed

TABLE I - Outcomes of studied population.

Outcomes	Number of patients (%)
At least one scan performed	211 (70.3%)
Ultrasound scans	137 (45.6%)
Open appendectomy	166 (55.3%)
Laparoscopic appendectomy	134 (44.7%)
Negative final histology	69 (23.0%)
Positive final histology	231 (77.0%)

TABLE II - Comparison between ultrasound results and final histology results.

Ultrasound results N(%)	Histology		P value
	Negative	Positive	
Negative	39(86.7)	61 (66.3)	0.014
Positive	6 (13.3)	31 (33.7)	

TABLE III - Evaluation of ultrasonography in predicting acute appendicitis.

Parameters	US
Sensitivity *	34 (0.24-0.43)
Specificity *	87 (0.77-0.97)
Positive predictive value*	84 (0.72-0.96)
Negative predictive value *	39 (0.29-0.49)
Diagnostic accuracy*	51 (0.42-0.59)
Odds ratio	3.303 (1.262-8.645)

* %, (95% Confidence Interval)

that overall they correlate statistically significantly with the histology results ($p=0.014$) (Table II), with specificity of 0.87 and sensitivity of 0.34 (Table III).

Discussion and Commentary

Many diseases closely mimic appendicitis and specific diagnosis is often made difficult by the varied presentation, the early non-specific examination findings, the inability of patients like children to accurately describe their symptoms and the commonly poor predictive value of laboratory testing, challenging the clinician to make an accurate diagnosis as early as possible. This consideration must be weighed against the risks inherent in the health and financial costs of excessive imaging. The main advantage of US is that it is easy to perform, but on the other hand inter-operator variability conduct is the main disadvantage of US^{3,8}. Furthermore, US sensitivity and the rate of visualization of the appendix on US vary across sites with all sites generally achieving consistently better results when the appendix is clearly visualized and when US is the primary imaging modality and therefore performed frequently.

In the current study sensitivity was relatively low compared to the range reported in literature (44-100%)^{2,3,5,7-14}, as was negative predictive value (NPV), with the latter though being within the literature range (33-97%)^{2,5,7-11,13,14}. Specificity was also comparable with the generally considered high specificities reported in literature (47-100%)^{2,3,5,7,14} and this is supported by the high positive predictive value (PPV) of the present study, in line with the reported literature (61.2-96.5%)^{2,5,7-11,13,14}. Nevertheless, the overall diagnostic accuracy of US in the present study was 51%, lying below the literature range (60 - 96%)^{2,7,9,13}. This can be explained by the relative low sensibility of the study which is possibly related to the fact that cases with non-identification of the appendix were included in the negative result group. Furthermore, US is mainly performed by sonographers and not by consultant radiologists, therefore affecting the results and the rates of visualization of the appendix, along with the coexistence of adult and paediatric

patients in this study. Several studies that present higher diagnostic accuracies are based on pure paediatric populations^{7,10,13}. The results are generally in line with the clinical practice in centres in United Kingdom where US commonly has a low sensitivity for appendicitis^{4,15}, which increases when the appendix is clearly identified. The visualization rate varies remarkably among institutions, from a high of 98% to a low of 22%^{10,13,16}. Difficult visualization is secondary to large body habitus, the presence of bowel gas, a non distended urinary bladder, extreme abdominal pain, an uncooperative patient and retrocecal and generally unconventional position of the appendix^{10,17}. Indeed, most of the false negative diagnoses at US, result from non-visualization of the appendix or from inflammation limited to the appendiceal tip⁸. Over recent years, various studies supported the hypothesis that a study without US visibility of the appendix might be able to rule out AA in specific patient populations and specific clinical settings^{4,6,16} and this justifies the inclusion of these cases in the negative group of the current study, similarly to other authors^{10,14,18}. This should apply when no secondary signs of appendicitis are seen (appendicolith, echogenic inflammatory peri-appendiceal fat change, free fluid)^{6,8,10}.

There are minimal data regarding the meaning of the term "non-diagnostic" US and great variability has been demonstrated in literature (13.9 - 81.4%)^{7,11}. However, in the current study the number of inconclusive or unclear cases was very low (5/142 patients, 3.52%). Generally, the definitions of positive and negative US and inconclusive results vary significantly in literature and the interpretation of equivocal cases and rates of non-visualization of the appendix can lead to confusion with regards statistical analysis¹⁶.

Because of its retrospective nature, the present study carries limitations. Clinical presentation was not considered therefore a selection bias may affect the results as the decision to perform an ultrasound relies on the physicians⁷. Moreover, although the graded compression technique is universally used, the use of any additional operator-dependent techniques to improve visualization was not documented.

US is not the gold standard in the diagnosis of appendicitis but in view of the advantages it appears that it should be performed as an adjunct to clinical assessment^{2,7,14}. A large meta-analysis performed in Korea a few years ago including 22 articles has supported the use of US for the diagnosis of AA, especially with young, male patients and with a high clinical suspicion¹³. The incorporation of ultrasonography into routine clinical practice performed by an expert is recommended, but only and exclusively to support other diagnostic elements and enabling minimization of need for CT, especially in young females, children and non obese males^{4,17}. Complementary Magnetic Resonance Imaging (MRI) or CT may be performed if the diagnosis remains unclear or the appendix is not definitively visualized by US^{3,4}.

Conclusion

The specificity of US in the current study and at most centres is generally considered high, supporting the clinical policy statement of the American College of Emergency Physicians that US is more useful to confirm acute appendicitis rather than exclude it¹⁹. However, a thorough clinical examination is still the best diagnostic procedure available in the diagnosis of AA which will probably remain a clinical one.

Riassunto

Scopo di questo studio è quello di valutare l'utilità degli ultrasuoni (US) quale metodo diagnostico in caso di appendicite acuta (AA) in un ospedale distrettuale mediante l'impiego di indici accurati di qualità.

Si è proceduto alla revisione delle cartelle cliniche di tutti i pazienti sottoposti ad appendicectomia nell'arco di un anno in un singolo centro, includendo nello studio quelli sottoposti pre-operatoriamente ecografico secondo criteri specifici, paragonando statisticamente a studio i risultati con lo studio istologico finale.

Si è trattato di 137 pazienti selezionati su queste condizioni, e 69 di essi (23%) hanno presentato risultati istologici negativi. In generale i risultati dell'ecografia sono risultati significativamente concordanti con i risultati istologici finali, con una specificità dello 0,87, una sensibilità di 0,34 ed un'accuratezza diagnostica generale dello 0,51

Si tratta di risultati concordanti con i dati della letteratura, che presenta un'alta specificità, ma una sensibilità relativamente bassa, sebbene esista una grande variabilità in letteratura. L'ecografia sembra utile per confermare piuttosto che per escludere l'AA.

Considerando i suoi vantaggi risulta raccomandabile l'adozione dell'ecografia nella routine corrente se effettuata da esperti, ma solo come supporto ad altri elementi diagnostici. L'elemento della scarsa sensibilità andrebbe indagato ulteriormente.

References

1. Al-Abed YA, Alobaid N, Myint F: *Diagnostic markers in acute appendicitis*. Am J Surg, 2015; 209(6):1043-47.
2. Sezer TO, Gulece B, Zalluhoglu N, Gorgun M, Dogan S: *Diagnostic value of ultrasonography in appendicitis*. Adv Clin Exp Med, 2012; 21(5):633-66.
3. Mittal MK, Dayan PS, Macias CG, Bachur RG, Bennett J, Dudley NC, et al.: *Performance of ultrasound in the diagnosis of appendicitis in children in a multicenter cohort*. Acad Emerg Med, 2013; 20(7):697-702.
4. Mostbeck G, Adam EJ, Nielsen MB, Claudon M, Clevert D, Nicolau C, et al.: *How to diagnose acute appendicitis: Ultrasound first*. Insights Imaging, 2016; 7(2):255-63.
5. Puylaert JB: *Mesenteric adenitis and acute terminal ileitis: US evaluation using graded compression*. Radiology, 1986; 161(3):691-95.
6. Estey A, Poonai N, Lim R: *Appendix not seen: the predictive value of secondary inflammatory sonographic signs*. Pediatr Emerg Care, 2013; 29(4):435-39.
7. Park JS, Jeong JH, Lee JI, Lee JH, Park JK, Moon HJ: *Accuracies of diagnostic methods for acute appendicitis*. Am Surg, 2013; 79(1):101-06.
8. Pinto F, Pinto A, Russo A, Coppolino F, Bracale R, Fonio P, et al.: *Accuracy of ultrasonography in the diagnosis of acute appendicitis in adult patients: Review of the literature*. Crit Ultrasound J, 2013; 5 Suppl 1:S2.
9. Karakas SP, Guelfguat M, Leonidas JC, Springer S, Singh SP: *Acute appendicitis in children: comparison of clinical diagnosis with ultrasound and CT imaging*. Pediatr Radiol, 2000; 30(2):94-98.
10. Pacharn P, Ying J, Linam LE, Brody AS, Babcock DS: *Sonography in the evaluation of acute appendicitis: are negative sonographic findings good enough?* J Ultrasound Med, 2010; 29(12):1749-55.
11. Lourenco P, Brown J, Leipsic J, Hague C: *The current utility of ultrasound in the diagnosis of acute appendicitis*. Clin Imaging, 2016; 40(5):944-48.
12. Doria AS, Moineddin R, Kellenberger CJ, Epelman M, Beyene J, Schuh S, et al.: *US or CT for diagnosis of appendicitis in children and adults? A Meta-Analysis*. Radiology, 2006; 241(1):83-94.
13. Yu SH, Kim CB, Park JW, Kim MS, Radosevich DM: *Ultrasonography in the diagnosis of appendicitis: Evaluation by meta-analysis*. Korean J Radiol, 2005; 6(4):267-77.
14. Shirah BH, Shirah HA, Alhaidari WA, Elraghi MA, Chughtai MA: *The role of preoperative graded compression ultrasound in detecting acute appendicitis and influencing the negative appendectomy rate*. Abdom Radiol (NY), 2016; 42(1):109-14.
15. D'Souza N, D'Souza C, Grant D, Royston E, Farouk M: *The value of ultrasonography in the diagnosis of appendicitis*. Int J Surg, 2015; 13:165-69.
16. Cohen B, Bowling J, Midulla P, Shlasko E, Lester N, Rosenberg H, et al.: *The non-diagnostic ultrasound in appendicitis: Is a non-visualized appendix the same as a negative study?* J Pediatr Surg, 2015; 50(6):923-27.
17. Ferrarese A, Falcone A, Solej M, Bono D, Moretto P, Dervishi N, et al.: *Surgeon's clinical valuation and accuracy of ultrasound in the diagnosis of acute appendicitis: A comparison with intraoperative evaluation. Five years experience*. Int J Surg, 2016; 33 Suppl 1:S45-50.
18. Hanna MK KZ, Hindosh LN, Hussain WA: *The role of ultrasound in the diagnosis of acute appendicitis: a prospective study*. The Iraqi Postgraduate Medical Journal, 2014; 13(2):226-29.
19. Howell JM, Eddy OL, Lukens TW, Thiessen ME, Weingart SD, Decker WW: *Clinical policy: Critical issues in the evaluation and management of emergency department patients with suspected appendicitis*. Ann Emerg Med, 2010; 55(1):71-116.

Commento e Commentary

PROF. GIANFRANCO GUALDI
Straordinario di Radiologia
Università "Sapienza" di Roma

L'argomento trattato è interessante in relazione al fatto che l'appendicite acuta è una delle emergenze più comuni in ambito chirurgico e l'appendicectomia rimane pur sempre l'intervento chirurgico più frequentemente eseguito.

La specificità degli ultrasuoni in questo studio è considerevole, a sostegno della strategia clinica che li considera maggiormente utili per confermare l'appendicite acuta piuttosto che ad escluderla.

Ritengo che questo articolo sarà interessante per i lettori del giornale perché lo studio dimostra l'accuratezza ed i limiti dell'ecografia nella diagnosi di appendicite e la loro importanza congiuntamente alla corretta valutazione clinica.

* * *

The topic of this article is interesting since the diagnosis of Acute appendicitis is one of the most common surgical emergencies and appendicectomy still remains among the most frequently performed surgery

The specificity of US in the current study is considered high, supporting the clinical policy that US is more useful to confirm acute appendicitis rather than exclude it.

I believe that this paper will be of interest to the readership of the journal because the study showed the accuracy and the limitation of US in detecting appendicitis and the importance of its together with the correct clinical evaluation.

READ-ONLY COPY
PRINTING PROHIBITED