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ORIGINAL RESEARCH ARTICLES

Added value of graded compression ultrasound to the Alvarado score in cases of right iliac fossa pain

Valeur Ajoutée De L'échographie De Compression Calibrée Au Score d'Alvarado En Cas De Douleurs Dans La Fosse Iliaque Droite

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Introduction: Acute appendicitis is one of the most common emergencies treated by the general surgeon. Simple appendicitis can progress to perforation, which is associated with a much higher morbidity and mortality, and surgeons have therefore been inclined to operate when the diagnosis is probable rather than wait until it is certain. The aim of this study was to evaluate the sensitivity and specificity of the Alvarado score combined with ultrasounds of the abdomen and pelvis in cases of right iliac fossa pain with suspected acute appendicitis.
Methods: 100 patients admitted to the Department of Surgery at Alexandria Main University Hospital in 2013 complaining of right iliac fossa pain with suspected acute appendicitis were studied prospectively. The demographic information, histopathology, physical examination, laboratory data, Alvarado score, sonography report and histopathological reports of these patients were gathered. The treating surgeon made decisions for surgery or conservative management without any intervention from the research team.
Results: A combination of methods showed that Alvarado alone was 100% sensitive in excluding appendicitis at scores below five and was highly specific at scores above eight (91.9%) with no added value when combining it with ultrasound in those scores. On the other hand, ultrasound was beneficial only in patients with Alvarado scores between five and eight for detecting appendicitis and not excluding it (increasing specificity to 100% and not affecting sensitivity).
Conclusion: Ultrasound is a good adjuvant examination in cases with Alvarado scores between five and eight in order to diagnose appendicitis. Negative ultrasound results do not exclude appendicitis and further assessment by other modalities should be performed.

Introduction: L'appendicite aigüe est l'une des urgences les plus courantes traitées par un chirurgien généraliste. L'appendicite simple peut évoluer en perforation, liée à une morbidité et une mortalité bien plus élevées, et les chirurgiens ont donc eu tendance à opérer lorsque le diagnostic était probable plutôt que d'attendre qu'il soit certain. Le but de cette étude était d'évaluer la sensibilité et la spécificité du score d'Alvarado associé à des échographies de l'abdomen et du bassin en cas de douleurs dans la fosse iliaque droite avec suspicion d'appendicite aigüe.
Méthodes: 100 patients admis au Service de chirurgie de l'Hôpital universitaire principal d'Alexandrie en 2013 se plaignant de douleurs dans la fosse iliaque droite avec suspicion d'appendicite aigüe ont été étudiés de façon prospective. Les informations démographiques, l'histopathologie, les examens physiques, des données de laboratoire, les scores d'Alvarado, les rapports d'échographie et les rapports histopathologiques de ces patients ont été rassemblés. Le chirurgien traitant a pris la décision d'une intervention chirurgicale ou d'une prise en charge prudente sans aucune intervention de l'équipe de recherche.
Résultats: Une combinaison des deux méthodes a montré qu'Alvarado seul était sensible à 100 % en termes d'exclusion de l'appendicite pour des scores inférieurs à cinq ans et était très spécifique pour des scores supérieurs à huit (91,89 %) sans valeur ajoutée constatée lors de sa combinaison avec une échographie pour ces scores. D'autre part, l'échographie n'a été bénéfique que chez les patients ayant des scores d'Alvarado situés entre cinq et huit pour détecter l'appendicite et non l'exclure (en augmentant la spécificité jusqu'à 100 % et sans incidence sur la sensibilité).
Conclusion: L'échographie est un bon examen complémentaire pour diagnostiquer l'appendicite dans les cas où les scores d'Alvarado se situent entre cinq et huit. Le résultats de l'échographie négatifs n'excluent pas l'appendicite et une évaluation plus poussée par d'autres modalités doit être effectuée.

African relevance

- Unnecessary appendectomies should be avoided.
- Ultrasound provides a quick examination, is easy to do and is low cost.
- Combining Alvarado scores and ultrasound may reduce unnecessary exams for some cases of suspected appendicitis.

Introduction

Appendicitis is one of the most common and most difficult surgical emergency conditions that can be diagnosed, and it may progress to peritonitis, which is associated with high mortality and morbidity. Decisions based on a bedside examination only result in the removal of normal appendices (i.e., useless operations) in 15–30% of cases.[1,2]

To avoid this situation, various investigative tools can be employed, including laparoscopy, clinical scoring systems,

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and different radiological modalities, such as ultrasonography, computed tomography (CT) scans and magnetic resonance imaging (MRI).

The Alvarado score is a representative clinico-laboratory scoring system that was chosen for this study due to its ease and speed of application in emergency centres in addition to the fact that it is a well-tested and widely available scoring system.[3] However, some surgeons are afraid of its low accuracy or its inapplicability to their communities.[4]

Radiological judgement has been a topic of debate in terms of the selection of the modality that should primarily be used, that is, ultrasound, CT or MRI, as well as the stratification of patients according to their needs for these techniques.

Ultrasound has the advantages of being quick, inexpensive, highly available, requiring no preparation by the patient, being potentially transportable, not requiring ionising emission or any contrast, and being potentially valuable in the diagnosis of other causes of abdominal pain and excluding different gynaecological pathologies.[5–7]

Despite the established superiority of CT over ultrasound in the diagnosis of appendicitis, recent studies have advocated for a first-line ultrasound approach for adult patients presenting with possible appendicitis.[8–11] This strategy has been found to be highly accurate when CT is reserved for patients with clinically suspicious negative or equivocal ultrasound results.[9,10,12] This diagnostic pathway has been demonstrated to be cost effective and to adhere to the principle of ALARA (as low as reasonably achievable) as well as the goal of the Image Gently campaign.[11,13]

Methods

This study included 100 consecutive patients with complaints of right lower abdominal quadrant pain with suspected acute inflammation of the appendix who were admitted to the surgical emergency centre of Alexandria Main University Hospital in 2013.

This research was approved by the ethics committee of Alexandria University, and informed consent was acquired from each of the patients while they were still in the emergency centre.

The exclusion criteria were the following: age below 12 years or above 65 years; mental retardation, and pregnant females.

The data collection team worked independently of the surgeons, radiologists and pathologists and did not interfere with the decisions made by the emergency surgery team or the radiologists.

The Alvarado scores were determined by the data collection team based on the patient's admission into the emergency centre before they were either examined by the surgeons on duty or underwent ultrasound examination. Next, all patients were examined by the radiologists and doctors immediately after being examined by the surgical team, regardless of their decision (the radiologists were blinded to the clinical findings) and the ultrasound results were classified as positive for appendicitis, negative for appendicitis, or equivocal.

'Negative for appendicitis' criterion was as follows: the appendix was not observed normally or pathologically identified. The equivocal criterion was: the appendix was observed but a non-considerable amount of free fluid with thickened, dilated, or non-peristaltic structure was observed in the right inferior quadrant of the abdomen. And the 'positive for appendicitis' criteria were as follows:

- Non-compressible, non-peristaltic blind tubular structure with an outer diameter of $\geqslant 6$ mms,
- Hyperechogenicity of the surrounding fat,
- The presence of an appendicolith (i.e., an intra-luminal echogenic focus with posterior shadowing),
- Peri-appendicular collection denoting perforation or abscess formation, and
- Hypervascularisation of the appendix as observed on colour Doppler.

All patients received intravenous fluids and parenteral antibiotics in the emergency centre. The patients that did not undergo surgery were followed-up in the hospital for 48 h (with coverage with intravenous fluids and parenteral antibiotics) and then discharged on a home medical treatment of antibiotic + antispasmodic for ten days, and the follow-up was continued for one month in the outpatient clinic.

Outcomes were investigated, and pathological reports for the patients who underwent operations were recorded. The collected data were sent to the Biostatistics Department for analysis, and the results were sent to the data collection team at the end of the research.

Results

This study included 100 patients, including 57 females (57%) and 43 males. The ages ranged from 14 to 48 years with a mean of 25.9 ± 8.2 years. Most (52%) of the patients were in the third decade of life, 26% in their second decade of life, and 22% were older than 30 years of age.

All patients presented with complaints of right iliac fossa pain, but only 53 patients reported a history of periumbilical pain shifting to right iliac fossa (migratory right iliac fossa pain). Seventy-four patients (74%) complained of anorexia, 85 patients (85%) complained of nausea, 53 patients (53%) had histories of vomiting, and 5 patients (5%) had histories of diarrhoea. Seventeen patients (17%) complained of constipation, and 12 patients (12%) had urinary complains related to dysuria or urinary frequency.

Forty-five patients (45%) were febrile with temperatures ranging from 37.4 to 38.6 degrees Celsius with a mean of 37.9 ± 0.4 degrees.

Total white blood cell (WBC) counts ranged from 800 to 24,000/μl with a mean of 11,900 ± 4900 cells. Taking 10,000 WBC/μl as the cut-off for leucocytosis, 66 patients (66%) had leucocytosis. Regarding the differential count, 62 patients (62%) had neutrophilia.

Ultrasounds were found to be positive in 46 patients, and all were found to be pathologically positive for appendicitis. Among the negative ultrasound cases ($n = 41$), 31 patients were definitively without appendicitis, and 10 patients had appendicitis (Table 1). Regarding the equivocal cases ($n = 13$), seven patients had appendicitis, and six were negative for appendicitis.

The studied patients had Alvarado scores ranging from four to ten with a mean of 7.3 ± 2.0. The Alvarado score

Table 1 Relationship between ultrasound and the final diagnosis of appendicitis.

	Appendicitis				χ^2	p
	+ve (n = 63)		**−ve** (n = 37)			
	n	%	n	%		
Ultrasound						
+ve	46	73.0	0	0.0	53.703*	< 0.001*
−ve	10	15.9	31	83.8		
Equivocal	7	11.1	6	16.2		

+ve, positive; −ve, negative; χ^2, Chi square test; *, statistically significant at $p \leqslant 0.05$.

has been shown to be sensitive in excluding appendicitis with scores under five with an overall sensitivity of 100%, and it is precise for diagnoses of appendicitis at scores of more than eight. With the newly mentioned Alvarado score seven as a cut-off value, a sensitivity of 76.2%, specificity of 59.5%, and precision of 70.0% was observed (Table 2). The cut-off of six yielded a sensitivity of 87.3%, a specificity of 48.7%, and an accuracy of 73.0%. Therefore, trans-abdominal sonography had a sensitivity of 73.0% and a specificity of 100% with a general precision of 83.0%.

Combining both the ultrasound results and Alvarado scores, when appendicitis was only diagnosed based on a positive ultrasound and an Alvarado score exceeding seven, we observed a sensitivity of 63.5% and a specificity of 100%, with an overall accuracy of 77% (Table 3). When an Alvarado score of more than six was used, the sensitivity increased to 69.8% and the accuracy increased to 81% with the same specificity.

On further assessment of this combination we found the following scenarios: All cases with Alvarado scores of 10 (n = 13) had positive ultrasounds and were positive for appendicitis (Table 4). Among the cases with Alvarado scores of 9 (n = 26), 19 patients had positive ultrasounds, and seven patients had negative ultrasound results. Three of these patients were pathologically proven not to have appendicitis, and the other four negative ultrasound patients had pathologically demonstrated appendicitis. The patients with Alvarado scores of four (n = 10) all had negative ultrasound results and were free of appendicitis.

Discussion

Appendectomies based only on clinical examination and experience results in the excision of non-pathological organs (i.e. negative appendectomies) in 15–30% of cases.[1,2]

This study included 100 patients with minimal sex differences; i.e., 57 females (57%) and 43 males (43%).The ages of the patients in this study were between 14 and 48 years, and the mean age was 25.93 ± 8.18 years. Other similar studies have failed to demonstrate substantial differences in mean

Table 2 Accuracies of ultrasound and the Alvarado score in the diagnoses of appendicitis.

		Appendicitis		Sensitivity	Specificity	PPV	NPV	Accuracy
		−ve	**+ve**					
Ultrasound	**−ve**	37	17	73.0	100	100	68.5	83.0
	+ve	0	46					
Alvarado score with cut-off (7)	**−ve**	22	15	76.2	59.5	76.2	56.5	70.0
	+ve	15	48					
Alvarado score with cut-off (6)	**−ve**	18	8	87.3	48.7	74.3	69.2	73.0

+ve, positive; −ve, negative; PPV, positive predictive value; NPV, negative predictive value.

Table 3 Sensitivity, specificity and accuracy using an Alvarado cut-off value with ultrasound.

Ultrasound & Alvarado score		Appendicitis		Sensitivity	Specificity	PPV	NPV	Accuracy
		−ve	**+ve**					
Cut-off (7)	**−ve**	37	23	63.5	100	100	61.7	77.0
	+ve	0	40					
Cut-off (6)	**−ve**	37	19	69.8	100	100	66.1	81.0

+ve, positive; −ve, negative; PPV, positive predictive value; NPV, negative predictive value.

Table 4 Sensitivity, specificity and accuracy of ultrasound and Alvarado scores.

Ultrasound & Alvarado score		Appendicitis		Sensitivity	Specificity	PPV	NPV	Accuracy
		−ve	+ve					
(4)	−ve	10	0	–	100	–	100	100
	+ve	0	0					
(5–8)	−ve	24	13	51.0	100	100	60.6	72.3
	+ve	0	14					
(9–10)	−ve	3	4	88.9	100	100	42.9	89.7
	+ve	0	32					

+ve, positive; −ve, negative; PPV, positive predictive value; NPV, negative predictive value.

age; i.e., the mean ages have ranged from 20 to 27 years in such studies.[1,7,14–16]

After right iliac fossa pain, which was present in all of the studied patients, nausea and anorexia were the most common associated symptoms (85% and 74% of the cases, respectively). Vomiting was observed in 53% of the cases, migratory right iliac fossa pain was observed in 43% of the cases, constipation was observed in 17% of the cases, urinary irritation symptoms were observed in 12% of the cases, and diarrhoea was observed in 5% of the cases. In a recent study performed by Merhi et al., nausea, vomiting and anorexia were the most commonly associated symptoms and occurred in 82.8%, 81% and 79.3% of the studied 232 patients, respectively. Diarrhoea was reported in 33% of their patients, and dysuria was reported in 12% of the patients.[17]

An Alvarado score of seven as the cut-off value yielded a sensitivity of 76.2%, a specificity of 59.5%, a positive predictive value of 76.2%, a negative predictive value of 56.5%, and an overall accuracy of 70.0%, whereas an Alvarado cut-off of six yielded a sensitivity of 87.3%, a specificity of 48.7%, a positive predictive value of 74.3, a negative predictive value of 69.2%, and an overall precision of 73.0%. Compared to other authors, we found that an Alvarado score below five had a very high sensitivity for ruling out appendicitis that reached 99.0%, as described in a meta-analysis published by Ohle et al.[18] In contrast, in the same meta-analysis, the authors demonstrated a sensitivity of 82.0% and a specificity of 81.0% using an Alvarado score of seven as the cut-off for the diagnosis of appendicitis; this value is higher than that of our current study results.[18] In a study published by Tade, the sensitivity was 100% based on scores below five, and the specificity was 100% based on an Alvarado score of 10.[19]

Notably, many studies have demonstrated increased specificity in the diagnosis of appendicitis based on an Alvarado score of eight or higher as mentioned by Althoubaity and Chan, et al.[20,21] However, these authors documented missing cases of appendicitis.

Therefore, the conclusion is as follows: an Alvarado score below five in our study and other studies is a sensitive tool for excluding appendicitis, and a score of nine or ten is relatively specific for the diagnosis of appendicitis.

In our study, ultrasound had an overall sensitivity of 73.0%, specificity of 100%, positive predictive value of 100%, negative predictive value of 68.5% and overall accuracy of 83.0%. In a study performed by Nasiri et al., abdominal sonography exhibited 71.2% sensitivity, 83.3% specificity and 72.4% accuracy[1]; whereas in the study performed by Gokce et al., the sensitivity was 69.0%, specificity was 60.0% and accuracy was 67.0%.[16] Khanal et al. reported a sensitivity of 85.7%, a specificity of 100%, a positive predictive value of 100%, a negative predictive value of 6.7% and an accuracy of 85.9% for ultrasound.[16] Based on a three-year study, Gracey et al. reported an overall sensitivity of 93.8% and a specificity of 91.3%.[22]

Combining the Alvarado score and ultrasound to achieve better diagnostic efficacy, we observed that an appendicitis diagnosis based on a positive ultrasound and an Alvarado score of seven or more yielded a sensitivity of 63.5%, a specificity of 100%, a positive predictive value of 100% and an overall precision of 77.0%, which is specific but not sensitive. Superior results were obtained when the combination included the Alvarado cut-off of six, which yielded a sensitivity of 69.8%, a specificity of 100% and an accuracy of 81.0%. Kurane et al. examined 60 patients who had undergone appendectomies and found that the Alvarado score alone had a sensitivity of 78.3%, a specificity of 83.8% and an overall precision of 81.0%. Ultrasound alone had a sensitivity of 82.6%, a specificity of 89.2% and an overall precision of 86.7%. In the same study, when these authors assessed cases with both high Alvarado scores and positive ultrasounds, the sensitivity improved to 88.8%, the specificity to 96.5% and the precision to 93.6%.[23]

In our study, the patients with Alvarado scores below five were all found by ultrasound to be negative for appendicitis and were ultimately proven by follow-up (with or without CT) to be free of appendicitis. Therefore, in these cases, ultrasound did not add any data.

In contrast, ultrasound was highly specific (100%) in the cases with Alvarado scores of six, seven and eight but was not very sensitive (51%). In other words, a positive ultrasound denotes 100% specificity for appendicitis, but a negative ultrasound cannot necessarily exclude appendicitis.

Parsijani et al. performed a study that assessed ultrasounds of only patients with Alvarado scores between four and seven. The authors found that ultrasound in these groups had an overall sensitivity of 75.0%, a specificity 69.2%, a positive predictive value of 88.0%, a negative predictive value of 46.1% and an accuracy of 73.6%.[24] In a similar study by Douglas et al., ultrasound was only performed in patients with scores between five and eight; patients with scores of nine and ten underwent appendectomies, and patients with scores between one and four were discharged. These authors found that their diagnostic protocol, which included the Alvarado score, was, if anything, safer, faster and more accurate than

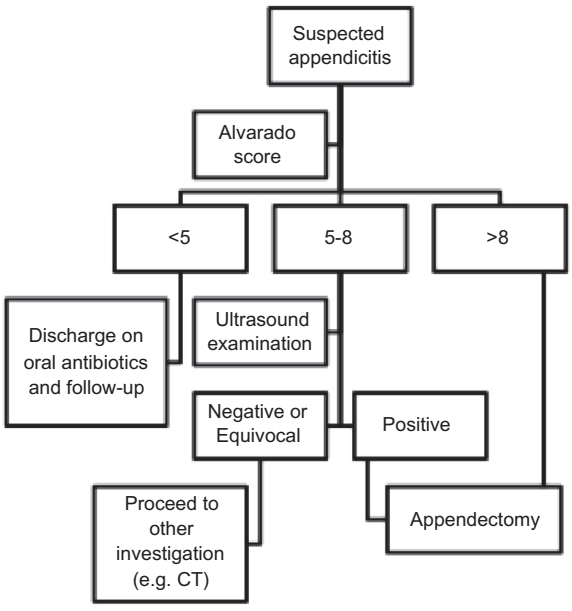

Figure 1 Algorithm for diagnosis in cases of suspected appendicitis.

graded compression of abdominal sonographic examination alone.[25]

A literature search related to the effects of such combinations revealed that most publications deny the role of ultrasound alone in rejecting appendicitis when the ultrasound is negative, but accept its added value in the diagnosis of appendicitis when the ultrasound results are positive; thus, clinical judgement should be the first priority.[23–27] Therefore, appendicitis is a clinical diagnosis that might be aided by radiological assessments in suspicious cases, but only for patients with Alvarado scores five to eight, as was observed in our study.

Conclusions

Alvarado scores can be used to stratify patients who need a radiological assessment; patients with scores below five can be discharged, and those with scores of more than eight should undergo operations (Fig. 1). Specifically, males and those with scores between five and eight should undergo further ultrasound investigations. If equivocal or negative results are observed with no other primary detection, CT should be performed. However, further prospective studies with larger study groups should be performed to validate our recommendations.

Conflict of interest

The authors declare no conflict of interest.

Author contributions

MS, was responsible for editing the paper, revising the data collection and results. MH, was responsible for data collection and editing. MG, Head of surgical team was responsible for decision making and operations. KM, was responsible for radiological examination and radiological data.

Dissemination of results

This article was presented in front of committee at Alexandria faculty of medicine for approval, and in order to unify the language spoken by different specialty (radiology, surgery, EC doctors), second to establish a system for stratification of patient in the EC.

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