



Efficacy of abdominal ultrasound in the diagnosis of patients with appendicitis: A single-center observational study.

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Abstract

Introduction: Acute appendicitis is one of the most frequent causes of acute abdominal pain, occurring with greater recurrence in the second and third decades of life. The diagnosis is clinical and is accompanied by laboratory tests and images such as abdominal ultrasound. This study aimed to determine the association between ultrasound findings and clinical diagnostic tests.

Methods: This was an observational, retrospective, and cross-sectional study. The data were extracted by reviewing medical records using a Microsoft Excel data collection sheet at the Alcívar Hospital from January 1, 2019, to December 31, 2019. A total sample of 152 patients was included.

Results: There was a significant dependency relationship between the number of ultrasound reports and the Alvarado scale score among the study participants. With an A score of 9-10 on the Alvarado scale, the presence of plastrons by ultrasound had an odds ratio (OR) = 6.4286 (1.9469-21.227) ($P = 0.0023$). The second ultrasound pattern associated with appendicitis with an Alvarado clinical score of 7-8 was the presence of peri-appendicular fluid (OR = 3.6111 [1.1651-11.1927], $P = 0.0261$). The last ultrasound pattern associated with acute appendicitis with an Alvarado clinical score of 7-8 was the presence of a thickened or enlarged appendix, with an OR = 3.4817 (1.7320-6.9989) ($P = 0.0005$).

Conclusions: Using ultrasound as an imaging medium provides a better parameter for diagnosing and following patients with acute appendicitis during surgery at the Alcívar Hospital.

Keywords:

Acute appendicitis, Alvarado scale, Ultrasound of the appendix, Vermiform appendix.

Abbreviations

BMI: Body mass index.

Supplementary information

No supplementary materials are declared.

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Authors' contributions

Annie Candy Saltos Cepeda: Conceptualization, data curation, formal analysis, acquisition of funds, research, writing - original draft.

Rene Mendoza Merchán: Acquisition of funds, Research, Methodology, Resources, Supervision, Validation, Visualization, Writing - original draft, Writing - review and edition.

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Availability of data and materials

The datasets used and analyzed during the present study are available from the corresponding author upon reasonable request.

Introduction

Acute appendicitis is one of the most frequent causes of acute abdominal pain, occurring with greater recurrence in the second and third decades of life, which is more than 22 years [1]. This pathology affects between 7% and 12% of the world's population, with a higher incidence for men (8.6%) and women (6.7%) of all age groups [1].

Currently, 45.9% of patients operated on for acute appendicitis in the United States benefit from early diagnosis and a lower risk of complications due to diagnostic imaging approaches, such as ultrasound, which has a high range of accessibility to the population because of its cost and reliability [2]. However, its use could be limited by the dependence of the operator, which generates doubt about its validity and safety for correlation in diagnostic evaluation and decision-making before a significant complication of the pathology [3].

Considering that the highest incidence of appendicitis cases ranges between 17 and 65 years of age and that the differential diagnoses of these patients with other pathologies are more varied and capable of presenting similar symptoms, this study is significant for confirming the validity and reliability of ultrasound during the diagnosis of acute appendicitis because of its easy availability as a resource in the daily management of patients [4].

Using ultrasound as an imaging medium is hypothesized to provide a better parameter for diagnosing and following patients with acute appendicitis in the surgery service of the Alcívar Hospital. This observational study aimed to determine the efficacy of abdominal ultrasound and its validity and reliability for the timely diagnosis of patients with acute appendicitis in Guayaquil, Ecuador.

Materials and methods

Study design

The present study is observational and cross-sectional. The source is retrospective.

Stage

This study was carried out at the Surgery Service of Hospital Alcívar in Guayaquil, Ecuador, from January 1, 2018, to December 31, 2020.

Participants

Adult patients older than 17 years were included, with an established diagnosis of acute appendicitis and a preoperative abdominal ultrasound. Patients with a diagnosis in the abdomen were excluded. Acute of undetermined origin. Patients with incomplete data were excluded from the analysis.

Variables

The variables were age, sex, clinical manifestations, ultrasound findings, treatment, time of disease onset, and surgical findings.

Data sources/measurements

The source was indirect; an electronic form was filled out from the history data. The International Classification of Diseases (ICD-10) was used to identify cases of appendicitis. The following codes were used for the search:

- K37 Appendicitis
- K35.9 Acute (catarrhal) (fulminant) (gangrenous) (obstructive) (retrocecal) (suppurative) appendicitis
- K35.1 Acute appendicitis with peritoneal abscess
- K35.0 Acute appendicitis, perforation, peritonitis, or rupture
- A06.8 Amoebic appendicitis
- K36 Healed appendicitis (obliterating)
- K35.1 Appendicitis with peritoneal abscess
- K35.0 Appendicitis with perforation, peritonitis, or rupture
- K36 Chronic (recurrent) appendicitis
- K36 NCOP-specified appendicitis
 - Appendicitis, exacerbation (see Appendicitis, acute)
 - Gangrenous appendicitis (see Appendicitis, acute)
- K37 Pneumococcal appendicitis
- K36 Obstructive appendicitis
- K36 Recurrent appendicitis
- K37 Retrocecal appendicitis
- K36 Subacute (adherent) appendicitis
 - Suppurative appendicitis (see Appendicitis, acute)
- A18.3 - K93.0 Tuberculous appendicitis.

The clinical manifestations of acute appendicitis were measured with the Alvarado scale [5], which provides the following scores:

- <5 points: excluded
- 5-6 points: possible.
- 7-8 points: probable.
- 9-10 points: very probable.

The ultrasound report described the following findings:

- Increase in size.
- Not an understandable appendix.
- Peri-appendicular fluid.
- Presence of plastron.
- The Appendix is not displayed.

The information was treated confidentially; no personal data were included to identify the study subjects.

Biases

To avoid possible interviewer, information, and memory biases, the principal investigator always maintained the data with a guide and records approved in the research protocol. Observation and selection bias were avoided by applying the participant selection criteria. Two researchers independently analyzed each record in duplicate, and the variables were recorded in the database once their agreement was verified.

Study size

In 2017, 38,533 cases of acute appendicitis were registered in Ecuador, representing a rate of 22.97 per 10,000 inhabitants. With a population of 2,671,801 inhabitants of Guayaquil at the end of 2018, this would represent 6137 cases as a study population. Using Epi Info™ (CDC Atlanta, USA, 2017) for the sample calculations with a confidence level of 95%, an expected frequency of 11.2%, and a confidence limit of 5%, the sample size was 149 patients.

Quantitative variables

Descriptive statistics were used. The results are expressed as frequencies and percentages.

Statistical analysis

Inferential statistics are used. For descriptive analysis, frequencies and percentages are presented. Risk associations are presented with Odds Ratio, 95% confidence interval, and Chi-square P value. The statistical package used was IBM Corp., Released in 2013. IBM SPSS Statistics for Windows, Version 22.0. Armonk, NY: IBM Corp.

Results

Participants

Of a total of 328 patients, 152 patients (46.34%) had available preoperative ultrasound data.

Main characteristics of the study group

The average age of the participants was 36 years. There were 56 women (36.8%) and 96 men (63.2%). According to the Alvarado scale, there were 96 patients (63.15%) with probable appendicitis, 20 patients (13.15%) with very probable appendicitis, and 36 patients (23.68%) with possible appendicitis.

Ultrasound findings

The majority of ultrasound findings consisted of the presence of a thickened or enlarged appendix in 78 patients (51.32%). In 32 patients (21.05%), the appendix was not visualized. Periapical fluid was present in 24 patients (15.79%),

appendicular plastron in 14 patients (9.21%), and nonunderstandable in 4 patients (2.6%).

Alvarado scale and ultrasound findings

The presence of plastron was the most critical risk factor for the “very probable” of acute appendicitis on the Alvarado scale (Table 1). The ultrasound findings and operative findings are presented in Table 2.

Operative findings

The most prevalent operative findings were an edematous appendix in 77 patients, a phlegmonous appendix in 26 patients, a retrocecal appendix in 24 patients, a necrotic appendix without perforation in 10 patients, and a perforated appendix with abscess in 14 patients. Table 2 presents the distribution of the patients classified according to the ultrasound findings.

Evolution time and ultrasound findings

Table 3 presents the distribution of the cases classified according to the time of evolution with the ultrasound findings. Most patients (34.87%) were diagnosed between 0 and 6 hours after symptom onset, and 27.92% were diagnosed within 7 to 12 hours of symptom onset.

Discussion

The main result of the study was that the presence of appendicular plastrons on ultrasound was associated with very high clinical scores in the Alvarado classification, with a score of 9-10 and an odds ratio (OR) = 6.4286 (1.9469-21.227) ($P = 0.0023$). The second ultrasound pattern associated with appendicitis with an Alvarado clinical score of 7-8 was the presence of peri-appendicular fluid (OR = 3.6111 [1.1651-11.1927], $P = 0.0261$). The last ultrasound pattern associated with acute appendicitis with an Alvarado clinical score of 7-8 was the presence of a thickened or enlarged appendix, with an OR = 3.4817 (1.7320-6.9989) ($P = 0.0005$).

The population data used in the present study do not vary from those used in previous reports. Seven percent of the total world population will have appendicitis at some stage of life, with a peak incidence between 10 and 30 years of age in both sexes, with a greater frequency in males (8.6%) and females (6.7%). In one study, 8.6% of the participants were men, and 6.7% were women [6]. According to all the medical records reviewed, men presented a greater frequency of this clinical picture [3,6], which could be explained by men presenting more typical findings for appendicitis and having fewer alternative etiologies for pain in RIF, increasing the probability of diagnosis.

Table 1. Ultrasound findings and Alvarado scale for the classification of appendicitis symptoms.

Ultrasound findings	Alvarado scale		
	Very probable (9-10) N=20	Probable (7-8) N=92	Possible (5-6) N=36
Nonunderstandable Appendix n = 4	0 (0%) OR=0.6748 (0.0350-13.008) <i>P</i> =0.7944 (N=9) (45%)	4 (4.35%) OR=5.7458 (0.3035-108.7727) <i>P</i> =0.2439 (N=59) (64.13%)	0 (0%) OR=0.3303 (0.0174-6.2838) <i>P</i> =0.4611 (N=10) (27.78%)
Thickened or increased in size n = 78	OR=0.6996 (0.2714-1.8036) <i>P</i> =0.4597	OR=3.4817 (1.7320-6.9989) <i>P</i>=0.0005	OR=0.2489 (0.1094-0.5662) <i>P</i>=0.0009
Periapendicular fluid n = 24	1 (5.0%) OR=0.2403 (0.0306-1.8869) <i>P</i> =0.1751	20 (21.74%) OR=3.6111 (1.1651-11.1927) <i>P</i>=0.0261	3 (8.33%) OR=0.3939 (0.1102-1.4078) <i>P</i> =0.1517
Plastron n = 14	6 (30.0%) OR=6.4286 (1.9469-21.227) <i>P</i>=0.0023	8 (8.70%) OR=0.7937 (0.2603-2.4201) <i>P</i> =0.6845	0 (0%) OR=0.0931 (0.0054-1.6003) <i>P</i> =0.1018
The appendix is not displayed n = 32	4 (20.0%)	5 (54.35%)	23 (63.89%)

Table 2. Ultrasound findings and operative findings of acute appendicitis.

Ultrasound findings	Phlegmonous	Edematous	Ret-ro-cecal	Necrotic without perforation	Peri-appendicular fluid	Perforated with abscess
Nonunderstandable Appendix n = 4	2	1	0	0	0	1
Thickened or increased in size n = 78	14	62	1	0	0	1
Peri-appendicular fluid n = 24	6	12	5	0	0	1
Plastron n = 14	3	0	0	7	0	4
The appendix is not displayed n = 32	1	2	18	3	1	7

Tabla 3. Hallazgos ecográficos y tiempo de evolución de la apendicitis aguda.

Ultrasound finding 136	Nonunderstandable Appendix n = 4	Thickened or increased in size n = 78	Periapendicular fluid n = 24	Plastron n = 14	The appendix is not displayed n = 32
0-6 horas n=53	1	26	8	0	18
7-12 horas n=43	2	27	10	1	3
13-18 horas n=3	0	2	1	0	0
19-24 horas n=26	0	12	3	3	8
25-30 horas n=0	0	0	0	0	0
31-36 horas n=0	0	0	0	0	0
37-42 horas n=0	0	0	0	0	0
43-48 horas n=11	0	7	1	2	1
>48 horas n=16	1	4	1	8	2

At a general level, clinic-guided scoring systems help identify patients at high or low risk of appendicitis. In this case, the Alvarado scale and its applicability as a clinical scoring system can help identify at-risk patients.

In this study, the points highlighted by the assessment of this scale were evaluated according to the reports of the clinical history of each patient, taking into account the following: migration of pain to the right iliac fossa (1 point), anorexia (1 point), nausea and/or vomiting (1 point), pain in the lower right quadrant (2 points), Blumberg's sign or rebound (1 point), temperature > 37.5 °C (1 point), and leukocytosis (2 points), which is the total sum of more than 10 points and is classified according to the following range: negative for appendicitis: <5 points, possible appendicitis: 5-6 points, probable appendicitis: 7-8 points, very probable appendicitis: 9-10 points; resulting in a score of probable appendicitis in 63.1%, followed by possible appendicitis with 23.6% and 13.1% for very probable appendicitis; and no patients with an Alvarado scale score less than 5 points [5].

Considering that 100% of the patients included in this study underwent surgery with an evident report of a revised surgical finding, we can consider this study to be valid, as well as other studies, the inclusion of this scale in the clinical assessment of adult patients who go to the emergency area.

However, to date, the timely diagnosis of this pathology continues to pose various difficulties despite the variability in the number and quality of diagnostic tests, especially images, which can be used for a more accurate and accurate early diagnosis. Several studies have reported a low sensitivity with a consequent number of false negatives, and a body mass index greater than 30 kg is used, especially in men, thus hindering the penetration of the ultrasonic beam and preventing clear visualization of the structures. Additionally, the retrocecal position where the gas is contained in the cecum or the ileum does not allow visualization of the viscera below them due to the acoustic shadow produced by the gas bubble.

According to a previous study [2], from the point of view of ultrasound diagnosis, 60.3% of the patients were diagnosed with appendicitis, and the general objective was to demonstrate the efficacy of ultrasound as a diagnostic method for this pathology. The variables of ultrasound findings were related to surgical findings, resulting in 120 patients—77.9% of patients out of 154 of the study sample—with ultrasound characteristics later confirmed during the surgical process. Therefore, the dependency relationship was significant and statistically supported the use of ultrasound as an accurate test and screening tool in the diagnosis of appendicitis, which allows the safe use of this low-cost resource; however, this method is

operator-dependent and requires adequate and continuous training and experience.

Conclusions

Ultrasound findings for the diagnosis of acute appendicitis are strongly associated with the Alvarado scale when a thickened or enlarged appendix is found and with the presence of plas-trons and perpendicular fluid.

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Declarations

Ethics committee approval and consent to participate

This study was approved by the Universidad de Católica Santiago de Guayaquil ethics committee.

Publication consent

It is not required when images, radiographs, and specific studies of patients are not published.

Conflicts of interest

The authors declare that they have no conflicts of interest.

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