# **Original Research Article**

DOI: http://dx.doi.org/10.18203/2349-2902.isj20170228

# The use of ultrasonographic and Alvarado scores in evaluating abdominal pain suggestive of acute appendicitis

Jorge Fernández Álvarez<sup>1</sup>, José Manuel Gómez López<sup>1</sup>, Alberto M González Chávez<sup>1\*</sup>, Benjamín Valente Acosta<sup>2</sup>, Diego Abelardo Álvarez Hénandez<sup>3</sup>, Silviano Ríos Pascual<sup>1</sup>, Alain Arturo García Vázquez<sup>1</sup>

**Received:** 30 November 2016 **Accepted:** 28 December 2016

# \*Correspondence:

Dr. Alberto M. González Chávez, E-mail: almagoch.md@gmail.com

**Copyright:** © the author(s), publisher and licensee Medip Academy. This is an open-access article distributed under the terms of the Creative Commons Attribution Non-Commercial License, which permits unrestricted non-commercial use, distribution, and reproduction in any medium, provided the original work is properly cited.

# **ABSTRACT**

**Background:** Ultrasonographic scores for appendicitis to determine if, combined with Alvarado scores, they can increase the sensitivity and specificity of the diagnosis of appendicitis.

**Methods:** All cases of abdominal pain suggestive of appendicitis presented between 2013 and 2015 were analysed. An Alvarado score was obtained. All patients underwent ultrasound, and an ultrasonographic score was determined, including the appendicitis classical findings.

**Results:** Two hundred and fifty-one patients with abdominal pain in the right lower quadrant were analysed. Appendicitis was confirmed in 211 (84%) patients. For these patients, the average Alvarado score was 7.95/10 ( $\pm 1.25$ ) vs. 5.7/10 ( $\pm 1.11$ ) for patients who did not have appendicitis (p < 0.001). In patients with confirmed appendicitis, the average ultrasonographic score was 2.48/6 ( $\pm 1.06$ ) vs. 0.6/6 ( $\pm 0.92$ ) for patients who did not have acute appendicitis (p < 0.001). The ultrasonographic score has a sensitivity of 90% and a specificity of 87% with only two parameters. The combination of the Alvarado and ultrasonographic scores decreased the percentage of negative appendectomies to 2.36% and increased the area under the curve by 0.970.

**Conclusions:** The sum of the Alvarado and ultrasonographic scores provides an efficient alternative for diagnosing abdominal pain suggestive of appendicitis and predicts which patients should undergo surgery with good certainty.

Keywords: Appendicitis, Alvarado score, Abdominal pain, Acute abdomen, Ultrasound, Ultrasonographic score

### **INTRODUCTION**

Diagnosing abdominal pain requires clinical expertise, as it involves a complex semiology. Acute appendicitis should be considered if pathology is found in the right lower quadrant (RLQ), as it remains the most common cause of emergency abdominal surgery. Of the tools used to help diagnose peritoneal irritation described in the literature, two play an important role in semiology, as they are the basis of characteristic clinical data: Murphy's

chronology and the Alvarado score.<sup>2-5</sup> Imaging studies also play an important role due to the low specificity of clinical manifestations; abdominal ultrasound and abdominal computed tomography (CT) are the most commonly used. Abdominal ultrasound was first used in 1986 by Puylaert, who reported 63 - 99% sensitivity and 71-100% specificity.<sup>6</sup> However, one disadvantage is that it is operator-dependent.<sup>7,8</sup> Abdominal CT with intravenous (IV) contrast is considered the gold standard for diagnosing appendicitis and has high sensitivity (99%) and specificity (97%). Its main disadvantages are

<sup>&</sup>lt;sup>1</sup>Department of Gastrointestinal Surgery, Hospital Español de México, México

<sup>&</sup>lt;sup>2</sup>Department of Internal Medicine, American British Cowdray Medical Center, México

<sup>&</sup>lt;sup>3</sup>Faculty of Health Sciences, Universidad Anáhuac Norte, México

the high cost and limited availability. It also involves radiation exposure, and allergic reactions to the contrast medium are a possibility.  $^{9-11}$  An Alvarado score  $\geq 7$  is useful to identify those patients who have a higher probability of acute appendicitis and therefore would require a surgical consultation or further diagnostic imaging.

However, it should not be used as the sole criterion for determining whether surgery is necessary in any patient group.<sup>4</sup> The aim of this study is to discuss the ultrasonographic score as an indicator of acute appendicitis, validate its application in a specific population, compare it with the Alvarado score and determine if the combination of both scores can increase the sensitivity and specificity of the diagnosis.

#### **METHODS**

We performed an observational and prospective study, including all cases of abdominal pain suggestive of appendicitis regardless of sex or age evaluated in the emergency room at Hospital Español de México from January 2013 to June 2015 using abdominal ultrasound. Alvarado scores were obtained through direct examination and clinical assessment performed in the emergency room by surgical residents of our hospital. Patients were classified into three different groups according to the score obtained and according to the literature: unlikely (1 to 3 points), probable (4 to 6 points) and very likely (7 to 10 points).<sup>3,12</sup>

Abdominal ultrasound was performed for all patients in the radiology department of our hospital by at least four blinded radiologists using high-definition equipment (Voluson ® E8 ultrasound scanner, GE Healthcare Ultrasound, Wauwatosa, WI, USA) with a new surface render mode, 'HD live' (5 - 9 MHz transducer). The ultrasonographic criteria considered for the design of the score were as follows: anteroposterior diameter > 6 mm, echogenic changes in the periappendicular fat, noncompressible tubular image, free fluid in the RLQ, "target sign", thickness of the appendicular wall > 2 mm and, presence of an appendicolith in the lumen of the appendix. We decided the criteria based on previous

reports by Puyalert et al, Rioux et al and Jeffrey et al. 6,13,14

The radiologist team was unaware of the proposed scoring. One point was given per each suggestive finding, and thus the score consists of a minimum of zero and a maximum of seven. The decision to perform surgery was made by the surgical team based on the standard of care of our hospital. The present study did not influence the decision. The final diagnosis of appendicitis was based on the pathology report.

Ultrasonographic scores were compared with Alvarado scores using a single-factor analysis of variance (ANOVA). Sensitivity and specificity for both scores was also calculated for patients with histopathologically determined appendicitis. Receiver operating characteristic (ROC) curves were obtained to represent the ratio of true vs. false positives and to determine a discrimination threshold and the higher sensitivity value to predict acute appendicitis.

# **RESULTS**

Two hundred and fifty-one patients (123 males and 128 females, average age 36.7 years) with abdominal pain suggestive of appendicitis were examined over a 30month period using ultrasound. Of these patients, 228 underwent surgical procedures. A diagnosis of appendicitis based on histopathology was confirmed in 211 patients (84%) and 2.36% (5/211) had no tumour or inflammatory disease and no other cause of abdominal pain found by laparoscopy. In patients with confirmed acute appendicitis, the average Alvarado score was 7.95 (± 1.25) out 10, making the diagnosis "very probable". Patients with discarded appendicitis had an average Alvarado score of 5.7 (±1.11), making the diagnosis "probable"; this is statistically significant (p < 0.001) (Table 1). In patients with confirmed acute appendicitis, the average ultrasonographic score was 2.48 (± 1.06) out of 7. For those whom a diagnosis of acute appendicitis was discarded, the average ultrasonographic score was 0.6 ( $\pm$ 0.92), which is statistically significant (p < 0.001) (Table 1).

Table 1: General characteristics of the studied population.

	Patients with appendicitis (n = 211)	Patients without appendicitis (n = 40)	P- value
Sex (M/F)	108/103 (51.2%/48.8%)	15/25 (37.5%/62.5)	NS
Age	38.72 (14.77)	34.62 (15.15)	NS
Alvarado score	7.95 (1.25)	5.7 (1.11)	<u>&lt;</u> 0.001
Ultrasonographic score	2.48 (1.06)	0.60 (0.928)	<u>&lt;</u> 0.001
Developmental stages of the appendicitis as told by Robbins	Stage 1: 17 (8.1%) Stage 2: 105 (49.8%) Stage 3: 52 (24.6%) Stage 4: 37 (17.5%)		

Table 2: Analyzed criteria for the design of the ultrasonographic score

Finding	Patients with appendicitis (n=211) N (%)	Patients without appendicitis (n=40) N (%)	OR (IC)	P- value
Anteroposterior diameter ≥6 mm	202 (95.7%)	9 (4.3%)	89.78 (32.28-249.66)	< 0.001
Ecogenic changes in the periapendicular fat	120 (56.9%)	9 (22.5%)	4.54 (2.06-10.01)	< 0.001
Non-compressible tubular image	111 (52.6%)	4 (10%)	9.99 (3.43-29.06)	< 0.001
Free liquid in the abdominal cavity	159 (75.4%)	33 (82.5%)	0.64 (0.27-1.55)	NS
Target sign	46 (21.8%)	2 (5%)	4.95 (1.15-21.37)	< 0.001
Thickness of the apendicular wall ≥2 mm	69 (32.7%)	3 (7.5%)	5.99 (1.78-20.12)	< 0.001
Appendicolith	21 (10%)	0 (0%)		0.022

Table 3: Developmental stages of the appendicitis as told by Robbins and its correlation with the ultrasonographic and Alvarado scores.

Developmental stages of the appendicitis	Ultrasonographic score Average±SD	Alvarado score Average±SD	P-value
Stage 1	1.76 (0.752)	7.29 (1.16)	< 0.001
Stage 2	2.22 (1.009)	7.80 (0.75)	< 0.001
Stage 3	3.12 (1.003)	8.02 (0.98)	< 0.001
Stage 4	3.84 (1.385)	8.59 (2.2)	< 0.001

In patients with acute appendicitis, the most frequently documented macroscopic stage was the suppurative one (49.8% of the cases). In those without acute appendicitis confirmed by the histologic diagnosis a haemorrhagic ovarian cyst was observed. For those who did not have an appendectomy, the most frequent diagnosis was gastroenteritis or ileitis.

The parameters included in the ultrasonographic score were also analysed, comparing the group of patients with confirmed appendicitis against the group without confirmed appendicitis. In the first group, the most frequent ultrasonographic findings were an anteroposterior diameter > 6 mm (95.7%) and free fluid in the abdominal cavity (75.4%). An appendicolith was present in only 10%. In patients without appendicitis, the most frequent ultrasonographic finding was free liquid in the RLQ (82.5%).

Comparing both groups, it was determined that an anteroposterior diameter of > 6 mm (OR 89.78 CI (32.28 - 249.66, p < 0.001) is the most important finding to diagnose appendicitis, followed by a non-compressible tubular structure (OR 9.9 CI (3.43 - 29.06, p < 0.001). The finding of free fluid in the RLQ was not considered because it contributed little to the diagnosis. Therefore, the definitive score was based on six possible findings,

with a minimum of 0 points and a maximum of 6 (Table 2, Figure 1).

Comparing the ultrasonographic score and the Alvarado score using an ANOVA demonstrated that a higher score for both is equivalent to a higher developmental stage (p < 0.001). However, it was also determined that the ultrasonographic score and not Alvarado score is best correlated to the developmental stage of acute appendicitis (Table 3).

Table 4: Sensitivity and specificity of the ultrasonographic score in our studied population.

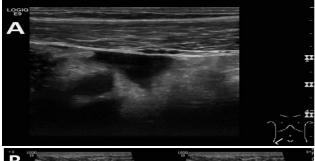
Ultrasonographic score	Sensitivity	Specificity
0	100%	0%
1	97.7%	65.8%
2	89.7%	86.8%
3	46.9%	97.4%
4	22.1%	100%
5	8.90%	100%
6	4.20%	100%

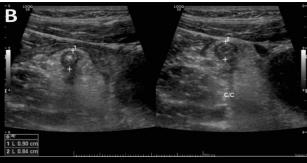
The sensitivity and specificity of each of the scores obtained in our studied population are presented in Table 4 and Figure 2. The mean area under the ROC curve for

the ultrasonographic score was 0.914 and 0.949 for the Alvarado score (Figure 2). With only two positive findings relating to the ultrasonographic score, a sensitivity of 89.7% and a specificity of 86.8% were achieved. However, an Alvarado score of 7 meant a sensitivity of 93.8% and specificity of 82.5%.

Table 5: Sensitivity and specificity of the ultrasonographic score in our studied population.

Alvarado score	Sensitivity	Specificity
5	99.1 %	10%
6	98.6 %	47.5%
7	93.8 %	82.5%
8	71.6 %	92.5%
9	28.9 %	97.5%
10	7.1%	100%









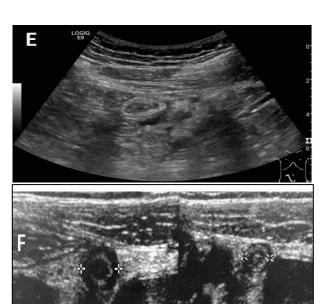




Figure 1: Ultrasonographic findings in acute appendicitis. A) Free liquid in the RLQ; B) noncompressible tubular image; C) anteroposterior diameter > 6 mm; D) thickness of the appendicular wall >2 mm; E) ecogenic changes in the periapendicular fat; F) target sign; G) appendicolith: calcified concretion in the appendix.

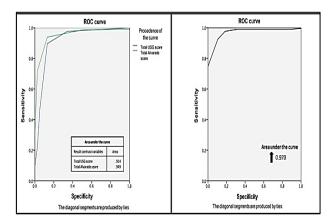


Figure 2: Receiver operating characteristic curves of both scores. A) ROC curve of the Alvarado and the ultrasonographic scores. B) ROC curve of the sum of the Alvarado and the ultrasonographic scores.

Table 6: Sensitivity and specificity of the sum of the Alvarado and ultrasonographic scores in our studied population.

Score (1-15)	Sensitivity	Specificity
1	100%	0%
3	99.5%	0%
5	99.1%	10.5%
6	99.1%	39.5%
7	99.1%	68.4%
8	97.7%	81.6%
9	92.5%	89.5%
10	74.6%	100%
11	49.8%	100%
12	26.3%	100%
13	14.6%	100%
14	8.50%	100%
15	3.80%	100%
16	1.40%	100%

Finally, both scores were summed up to determine if together they may offer an advantage by increasing the sensitivity and specificity of the diagnosis of acute appendicitis (Table 6). The result was an increase of 0.97 in the area under the curve (Figure 2).

#### **DISCUSSION**

In the studied population, a diagnosis of appendicitis was confirmed in 84% of the patients. This could be due to both the attendance of surgery residents 24 hours a day during the whole week in the emergency room and patients' sociocultural level. Several studies have reported diagnostic efficiency using physical exploration and lab studies vs. ultrasound and CT, demonstrating that when abdominal pain in the RLQ is assessed by a surgeon, sensitivity reaches more than 84%. 9,15-18 Sonographers use graded compression and the three-step sequential positioning algorithm as a standard protocol. 6 In 12% of patients in this study, it was impossible to visualize the cecal appendix. 13,19

Several publications verify the sensitivity of the Alvarado score when it reaches 9 or 10.8 In our study, when Alvarado scores (7 or higher) and ultrasonographic scores (2 or higher) matched, ultrasound sensitivity (92.5%) and specificity (89.5%) reached similar values to the tomography ones. Other authors suggest the lack of utility of CT if the score is 9 or higher. 20,21

In our study, patients with no appendicitis had an average Alvarado score of 5.7 and an average ultrasonographic score of 0.6, suggesting that lower scores can be found in patients with right iliac fossa pain without acute appendicitis. Blintman et al. state that with no conclusive ultrasound and an Alvarado score < 5, a negative predictive value of 96.5% is reached.<sup>22</sup> Like an study by Gujar et al., we found that the combination of Alvarado

and ultrasonographic scores decreased the percentage of negative appendectomies, suggesting that the combination of both declines unnecessary surgery.<sup>23</sup>

Appendicitis is a common surgical pathology, but its diagnosis continues to be a challenge for surgeons. Clinic, undoubtedly, provides most of the diagnostic suspicion and nowadays, imaging studies are performed routinely in some hospital centres to confirm or reject it. However, despite advances in radiology, currently there is no laboratory or imaging study able to confirm a diagnosis of acute appendicitis.<sup>9</sup>

The Alvarado score has been adopted by several centres as a clinical tool to stratify the level of suspicion regarding appendicitis and to help in the decision-making process. <sup>10</sup> Ultimately, surgeons must determine whether a patient requires surgery based on clinical, laboratory and imaging findings. In the present study, the Alvarado score had a sensitivity of 93.8% and specificity of 82.3%, confirming it is an excellent tool to identify patients with appendicitis when the score is 7 or more. Furthermore, all patients with a score of 7 or more (except one who was diagnosed with appendagitis) underwent surgery.

In our study, abdominal ultrasound was performed in 251 patients, 35 of whom needed an abdominal CT with IV contrast to complete the diagnosis. Of the 211 patients appendix inflammation confirmed histopathology, only 20 (9.47%) needed an abdominal CT with IV contrast. This places our hospital in a unique situation because despite being a private hospital with three tomographs available 24 hours a day, the acute appendicitis diagnosis was performed using only ultrasonographic and Alvarado scores in 90.5% of the cases. After statistical analysis, it was determined that the ultrasonographic score reached a sensitivity of almost 90% and a specificity of almost 87% with only two positive parameters, very similar to CT. Furthermore, even when ultrasounds were performed by four different radiologists, a score of 0 was obtained for only seven patients (2.78%), the diagnosis of acute appendicitis was confirmed by histopathology for four of these patients. This means that abdominal ultrasound lacks utility in 2% of patients with acute appendicitis.

Using both the Alvarado and ultrasonographic scores, areas under the curve were significant for predicting the diagnosis of acute appendicitis. This, coupled with a negative appendectomy rate of only < 3 percent.

An appendicolith appeared in just 10% of the cases, similar to the reports of other authors; this is the least frequent finding. In addition, after a multivariate logistic regression analysis, we also concluded that the gender of the patient was not important in predicting acute appendicitis using the ultrasonographic score.<sup>24</sup>

As there are no pathognomonic signs or symptoms or laboratory tests with an adequate predictive value, with the clinical presentation of appendicitis being so variable and considering that any delay in diagnosis increases the chances of morbidity and mortality, imaging studies should always be considered. The disadvantage of ultrasound is that it is operator-dependent; however, its ability to provide certain data in combination with clinical and laboratory findings, including the Alvarado score, makes it a good method of confirming the diagnosis of appendicitis. Although diagnosis exclusion cannot be done precisely, the combination of clinical findings and ultrasonographic scores may increase the degree of certainty and should be considered the first step in diagnosing abdominal pain suggestive of acute appendicitis, especially in centres where CT is not available.

# **CONCLUSION**

Individually, the Alvarado and ultrasonographic scores are useful to identify cases of acute appendicitis and are both correlated with the developmental stage. The combination of both increases the sensitivity and specificity of the diagnosis of appendicitis, as is reported in the literature for abdominal CT with IV contrast. In addition, the sum of both scores provides an efficient alternative for diagnosing abdominal pain suggestive of acute appendicitis that saves time and money, avoids the adverse effects of CT and predicts well which patients should undergo surgery.

Like other authors, we suggest ultrasound as an initial imaging tool to help diagnose abdominal pain, regardless of age or sex and that tomography should be restricted for those patients with Alvarado scores < 5 and no findings upon ultrasonographic evaluation. If ultrasound is positive and agrees with clinical findings, there is no need to perform additional imaging studies.<sup>25-27</sup>

Funding: No funding sources Conflict of interest: None declared

Ethical approval: The study was approved by the

institutional ethics committee

#### **REFERENCES**

- 1. Humes DJ, Simpson J. Acute appendicitis. BMJ. 2006;333:530-4.
- 2. Rocha A, Fernández O, Rodríguez E. Valoración de la secuencia de Murphy como elemento clínico en la apendicitis aguda. 2011;9:1-7.
- 3. Alvarado A. A practical score for the early diagnosis of acute appendicitis. Ann Emerg Med. 1986;15:557-64.
- 4. Ohle R, O'Reilly F, O'Brien K. The Alvardo score for predicting acute appendicitis: a systematic review. BMC Medicine. 2011;9:139.
- 5. Brahmanchari S, Jajee A. Alvarado score: a valuable clinical tool for diagnosis of acute appendicitis a retrospective study. J Med Allied Sci. 2013;3:63-6.

- 6. Puylaert JB. Acute appendicitis: US evaluation using graded compression. Radiology. 1986;158:355-60.
- 7. Pinto F, Pinto A, Russo A. Accuracy of ultrasonography in the diagnosis of acute appendicitis in adult patients: review of the literature. Crit Ultrasound J. 2013;5:2.
- 8. Subash K, De A, Pathak M. Diagnostic role of ultrasonography in acute appendicitis: a study at a terciary care hospital. American Journal of Public Health Research. 2015;5(3):23-8.
- 9. Birnbaum B, Wilson S. Apppendicitis at the millenium. Radiology. 2000;215:337-48.
- 10. Shogilev D, Duus N, Odom S. Diagnosing appendicitis: evidence-based review of the diagnostic approach in 2014. West J Emerg Med. 2014;15:859-71.
- 11. Lee S, Ho S. Ultrasonography and computed tomography in suspected acute appendicitis. Semin Ultrasound CT MR. 2003;24:69-73.
- 12. Jones R, Jeffrey R, Shah B. Journal club: the alvarado score as a method for reducing the number of ct studies when appendiceal ultrasound fails to visualize the appendix in adults. Am J Roentgenol. 2015;204:519-26.
- 13. Rioux M. Sonographic detection of the normal and abnormal appendix. AJR American Journal of Roentgenology. 1991;158:773-8.
- 14. Jeffrey R, Jain K, Nghiem H. Sonographic diagnosis of acute appendicitis: interpretive pitfalls. AJR Am J Roetgenol. 1994;162:55-9.
- 15. Gurleyik E, Guryelik G, Unalmiser S. Accuracy of serum c- reactive protein measurements in diagnosis of accute appendicitis compared with surgeon's clinical impression. Dis Colon Rectum. 1995;38:1270-4.
- Andersson R, Hugander A, Ravn H. Repeated clinical and laboratory examinations in patients with an equivocal diagnosis of appendicitis. World J Surg. 2000;24:479-85.
- 17. Kidd L. The diagnosis of acute appendicitis: clinical assessment versus computed tomography evaluation. J Emerg Med. 2001;21:119-23.
- 18. Merhi B, Khalil M, Daoud N. Comparision of alvarado score evaluation and clinical judgment in acute appendicitis. Medical Archives. 2014;68:10.
- 19. Chang S, Jeffrey R, Olcott E. Three-step sequential positioning algorithm during sonographic evaluation for appendicitis incrases appendiceal visualization rate and reduces CT use. Am J Roentgenology. 2014;203:1006-12.
- Toprak H, Kilincaslan H, Ahmad I. Integration of ultrasound findings with Alvarado score in children with suspected appendicitis. Pediatrics International. 2014;56:95-9.
- 21. Srinivasan A, Servaes S, Peña A. Utility of CT after sonography for suspected appendicitis in children: integration of clinical scoring system with a staged imaging protocol. Emergency Radiology. 2015;22:31-42.

- 22. Blitman N, Anwar M, Brady K. Value of focused appendicitis ultrasound and Alvarado score in predicting appendicitis in children: can we reduce the use of CT? AJM American Journal of Roentgenology. 2015;204:707-12.
- 23. Gujar N, Mudhol S, Kumar R, Choudhari S. Determination of sensitivity and specificity of modified alvarado score and ultrasonography in patients with acute appendicitis. J Krishna Institute Med Science. 2015;4:89-99.
- 24. Terasawa T, Blackmore C, Bent S. Systematic review: computed tomography and ultrasonography to detect acute appendicitis in adults and adolescents. Annals Internal Medicine. 2004;141:537-46.
- 25. Orr R, Porter D, Hartman D. Ultrasonography to evaluate adults for appendicitis: decision making

- based on meta-analysis and probabilistic reasoning. Acad Emerg Med. 1995;2:644-50.
- 26. Poletti P, Platon A, Deperrot T. Acute appendicitis: prospective evaluation of a diagnostic algorithm integrating ultrasound and low-dose CT to reduce the need of standar CT. European Radiology. 2011;21:2558-66.
- 27. Pare J, Langlois B, Scalera S. Revival of the use of ultrasound in screening for appendicitis in young adult men. J Clinical Ultrasound. 2016;44:3-11.

Cite this article as: Álvarez JF, López JMG, Chávez AMZ, Acosta BV, Hénandez DAA, Pascual SR, et al. The use of ultrasonographic and Alvarado scores in evaluating abdominal pain suggestive of acute appendicitis. Int Surg J 2017;4:757-63.