

Diagnostic utility of the Alvarado scale in older adults with suspected acute appendicitis

Utilidad diagnóstica de la escala de Alvarado en adultos mayores con sospecha de apendicitis aguda

Luis C. Domínguez-Torres* and Neil V. Vega-Peña

Departamento de Cirugía, Universidad de La Sabana, Chía, Colombia

Abstract

Background: Acute appendicitis remains as a differential diagnosis in older patients with abdominal pain. The Alvarado scale may assist to guide the diagnosis and treatment of this entity. The operative characteristics of the scale are little known in this population. **Method:** We conducted a systematic review of original studies published between 1986 and 2022 evaluating the diagnostic performance of the Alvarado scale in older adults with suspected acute appendicitis. The review was conducted according to the PRISMA statement. The evaluation of the methodological quality of the studies was performed according to the ROBINS-I criteria. **Results:** Four original studies of retrospective design including 480 patients were identified. The heterogeneity and poor methodological quality limited an aggregate statistical analysis (meta-analysis). The value of the ROC curve of the scale varies between 0.799 and 0.969. From the available studies, the value of the ROC curve is lower in comparison to the RIPASA scale and comparable to the Lintula scale. **Conclusions:** The evidence on the diagnostic performance of the Alvarado scale in older adults is limited. The poor methodological quality of the available studies calls for a prudent use of this tool in this population. Our findings offer opportunities for future research.

Keywords: Acute appendicitis. Alvarado score. Prediction. Elderly. Acute abdominal pain.

Resumen

Antecedentes: La apendicitis aguda es un diagnóstico diferencial en el adulto mayor con dolor abdominal. La escala de Alvarado se utiliza para orientar el diagnóstico y el tratamiento. Las características operativas de la escala son poco conocidas en este grupo de pacientes. **Método:** Revisión sistemática de estudios originales publicados entre 1986 y 2022 que evaluaron el rendimiento diagnóstico de la escala de Alvarado en adultos mayores con sospecha de apendicitis aguda, con base en la declaración PRISMA. La evaluación de la calidad metodológica de los estudios se realizó con los criterios ROBINS-I. **Resultados:** Se identificaron cuatro estudios originales de diseño retrospectivo que incluyen 480 pacientes. La heterogeneidad y la baja calidad metodológica limitaron un análisis estadístico agregado (metaanálisis). El valor de la curva ROC de la escala varía entre 0.799 y 0.969. En los estudios disponibles, el valor de la curva ROC es inferior al de la escala RIPASA y similar al de la escala de Lintula. **Conclusiones:** La evidencia que sustenta el rendimiento diagnóstico de la escala de Alvarado en los adultos mayores es limitada. La pobre calidad de los estudios disponibles advierte sobre el uso prudente de esta herramienta en este grupo poblacional. Los hallazgos identificados ofrecen oportunidades de investigación futura.

Palabras clave: Apendicitis aguda. Escala de Alvarado. Predicción. Adulto mayor. Dolor abdominal agudo.

*Correspondence:

Luis C. Domínguez-Torres

E-mail: carlosdot@unisabana.edu.co

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Introduction

The lifetime prevalence of acute appendicitis is around 7-8%¹. With the increase in life expectancy, the prevalence of acute appendicitis has also risen in the population older than 65 years^{2,3}. In this group of patients, the prevalence is similar to that of the general population, yet the perforation rate is higher (35% vs 13%)⁴. Additionally, it is well known that with age, the occurrence of inflammatory, vascular, and oncological abdominal conditions, among others, increases, and older adults make up a significant proportion of patients visiting the ER for this reason⁵. Acute appendicitis continues to be a cause of acute abdominal pain in about 15% of cases and represents the second leading cause of abdominal pain after biliary disease⁴. For these reasons, it is advisable to stratify the probability of acute appendicitis in all patients to guide diagnosis and treatment⁶. Generally, those with a high probability of appendicitis should undergo surgery, those with a low probability should be observed on an outpatient basis, and those in a gray area or with diagnostic uncertainty should be evaluated with imaging modalities, ideally contrast-enhanced abdominal computed tomography. This type of stratification is conducted using diagnostic scales that combine symptoms, physical examination findings, and biochemical tests. The most recommended are the Alvarado and the Appendicitis Inflammatory Response (AIR) scales⁶. The Alvarado scale, in particular, is accepted by the scientific community due to the extensive body of empirical evidence supporting it since the 1980s⁷. In its original version, the scale was developed to assess the probability of acute appendicitis in the general population⁸. However, the performance of the Alvarado scale is not entirely known in older adults. These patients represent a special population, along with children, pregnant women, and immunosuppressed patients. For this reason, careful evaluation is recommended in the presence of other abdominal conditions, as well as due to the coexistence of chronic diseases, drug use, frailty, cognitive changes, and functional changes, among others. These reasons lead many surgeons and institutions, as part of safe care, to evaluate all older adults with diagnostic imaging, regardless of the score, or even without applying any diagnostic scale. Nevertheless, in the routine clinical practice, it is common for older adults to continue to be stratified with scales in the same way as the general population. Given this controversy in the diagnostic approach of

older adults with acute abdominal pain, the objective of this study was to review the available evidence on the performance of the Alvarado scale in the probability of acute appendicitis in this population.

Method

We conducted a systematic review of the diagnostic test literature based on the PRISMA (Preferred Reporting Items for Systematic reviews and Meta-Analyses) statement⁹. This study was approved by University of La Sabana School of Medicine Research Commission (MEDEsp-41-2020).

Study selection

The inclusion criteria were original studies published in English or Spanish that evaluated the diagnostic performance of the Alvarado scale (individually or vs other scales) in adults older than 65 years old with clinical suspicion or diagnosis of acute appendicitis. For this purpose, clinical trials, prospective and retrospective cohort studies, and case series published from January 1986 through December 2022 were selected. Narrative literature reviews, letters to the editor, abstracts, posters, and conference presentations were excluded.

The search was conducted across the PubMed, Scopus, LILACS, Cochrane, and BIREME databases. The following English keywords were used: "Alvarado scale," "Alvarado score," "acute appendicitis," "elderly," "older adults," "diagnostic scale," "predictive scale," and "appendectomy." The following Spanish keywords were used: "escala de Alvarado," "puntaje de Alvarado," "apendicitis aguda," "ancianos," "adultos mayores," "escala diagnóstica," "escala predictiva," and "apendicectomía." The search also included cross-references. The titles and abstracts of all articles were independently evaluated by each author and then selected.

Outcomes

- Primary: Operational characteristics of the Alvarado scale. The ideal cut-off points, ROC (Receiver Operating Characteristics) curve values, sensitivity, specificity, positive predictive value, negative predictive value, positive likelihood ratio, negative likelihood ratio, diagnostic accuracy, and discriminative capacity were evaluated.
- Secondary: Morbidity, mortality, readmission, hospital stay, and costs.

Data mining from studies

The following demographic data were obtained from each study: author, year of publication, country, study design, objective, method, population, sex, age, duration of symptoms, mean Alvarado scale score, population distribution on the Alvarado scale, histopathological study, and use of complementary diagnostic tests. Then, the data corresponding to the proposed outcomes were extracted.

Quality assessment of the available evidence

This was performed by consensus between the 2 authors of the review following the ROBINS-I (Risk Of Bias In Non-randomized Studies - of Interventions) criteria¹⁰.

In each study, the following types of biases were identified: confounding, selection of study participants, classification of interventions, deviations from intended interventions, missing data, outcome measurement, and selection of the reported result.

Statistical analysis

Descriptive statistics were calculated for demographic variables. Continuous variables were expressed as means, standard deviations, and ranges. Categorical variables were expressed as frequencies and percentages. Based on the results of the methodological quality assessment, if homogeneity in the studies was identified, an aggregate statistical analysis of the data (meta-analysis) was planned.

Results

Characteristics of studies and demographic aspects

Four studies met the criteria for inclusion in the systematic literature review¹¹⁻¹⁴. The flowchart for the study selection is presented in figure. 1. Two studies (50%) were conducted in Turkey^{11,12}, and the other two in the United States^{13,14}. All were retrospective in design; two were cohort studies, and the other two, case series. Two studies compared the performance of the Alvarado scale with the Raja Isteri Pengiran Anak Saleha Appendicitis (RIPASA) scale¹¹ and the Lintula scale¹². In all studies, the Alvarado scale scores were calculated retrospectively.

The selected studies included a total of 480 patients. The rate of women ranged between 42% and 58.3%. In 2 studies, the diagnosis of acute appendicitis was achieved by computed tomography in more than 95% of the patients^{13,14}. Other demographic aspects of the population are shown in Table 1.

The assessment of the methodological quality of the studies is found in Fig. 2. In general, the included studies demonstrated a high risk of bias and methodological heterogeneity, limiting the ability to conduct an aggregate statistical analysis (meta-analysis).

Diagnostic operational characteristics of the Alvarado scale

Two studies reported the ROC curve of the Alvarado scale vs other scales. The ROC curve value of the Alvarado scale, with a cut-off point > 4 vs the RIPASA scale, was 0.799 vs 0.886¹¹. With a cut-off point > 5, vs the Lintula scale, the ROC curve value was 0.969 vs 0.921¹². Diagnostic accuracy was only reported by 1 study (88.7%)¹². Other operational characteristics are described in Table 2.

Regarding the discriminative capacity of the scale, regardless of the severity of acute appendicitis, 1 study reported that the distribution of patients was similar when the score was ≥ 7 (complicated = 61.8, uncomplicated = 63.2; p not significant)¹³. However, the diagnostic operational characteristics of the scale concerning the severity of appendicitis were not reported in any study.

Secondary outcomes

According to the available information in 2 studies, the complication rate varied between 22% and 37%^{13,14}. The reoperation and mortality rates reported in 1 study were 1.2% and 5.3%, respectively¹⁴. The negative appendectomy rate was reported in 1 study (24.4%)¹¹. No study included financial information. No study reported either on the behavior of secondary outcomes based on the Alvarado scale score. Other findings are shown in table 3.

Discussion

The results of this review indicate that there is a limited number of original studies, of poor methodological quality, on the utility of the Alvarado scale in predicting acute appendicitis in older adults. Two studies compare the diagnostic performance against the RIPASA and Lintula scales, respectively; in these, the ROC

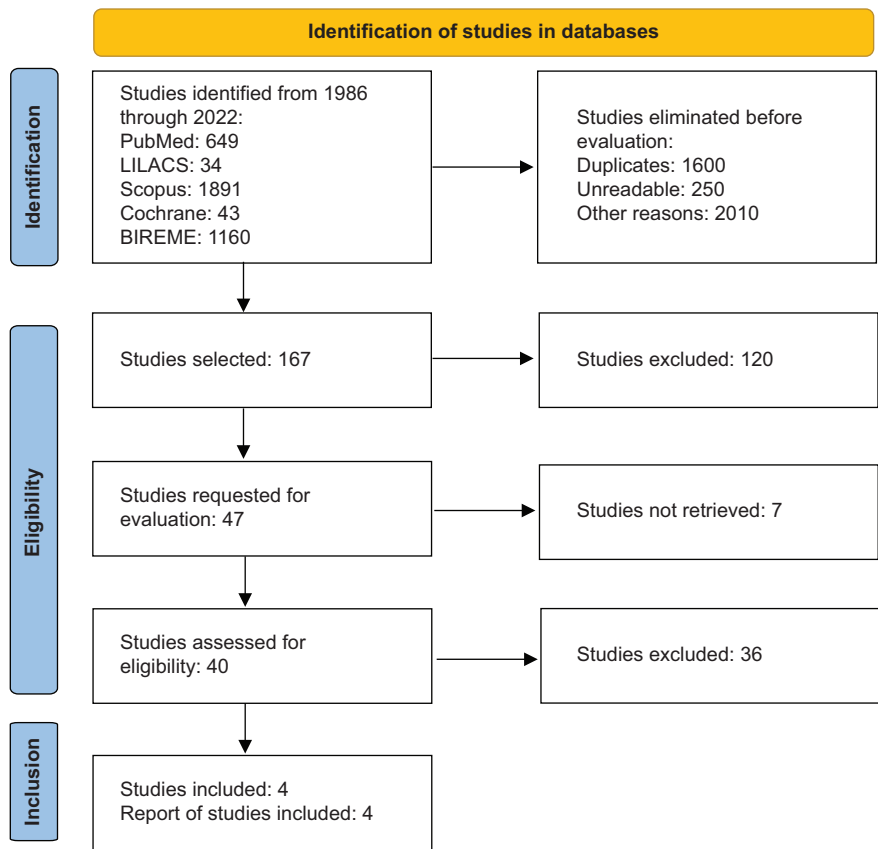


Figure 1. Flow diagram following the PRISMA statement.

		Risk of bias domains							
		D1	D2	D3	D4	D5	D6	D7	Overall
Study	Study 1								
	Study 2								
	Study 3								
	Study 4								

Domains:

D1: Bias due to confounding.
D2: Bias due to selection of participants.
D3: Bias in classification of interventions.
D4: Bias due to deviations from intended interventions.
D5: Bias due to missing data.
D6: Bias in measurement of outcomes.
D7: Bias in selection of the reported result.

Judgement

Critical
 Serious
 Moderate
 Low

Figure 2. Assessment of the methodological quality of the included studies.

Table 1. Characteristics of the studies included in the review

Authors	Country/Year/Design	Objective	Methods	Population	Age (years)	Women (%)	Symptom duration (days)	Mean score	Score distribution	BMI	Comorbidity (%)	Positive disease (%)	Diagnostic imaging (%)
Tekyol et al. ¹¹	Turkey, 2022	Retrospective cohort (2018-2021)	Evaluate the diagnostic accuracy of RIPASA and Alvarado in older adults operated for acute appendicitis	Researchers identified patients > 65 years old who underwent surgery (with or without pathological confirmation). Alvarado and RIPASA scores were calculated retrospectively.	86	71.2 ± 5.9	ND	3.48-5.29	ND	ND	ND	75.6	ND
Deiters et al. ¹³	United States, 2019	Retrospective case series (2012-2016)	Determine the utility of the Alvarado scale to identify complicated vs. uncomplicated acute appendicitis	Researchers identified patients > 65 years old who underwent surgery and had a pathological diagnosis. Alvarado scores were calculated retrospectively.	100	72.9 ± 6.9	2.70 ± 3.41	6.96 ± 1.99	≥ 7: 61.8% ≥ 7: 63.2%	28.5 ± 6.3 28.7 ± 5.3	26.2 31.6	100	99.1% (CT)
Shchatsko et al. ¹⁴	United States, 2017	Retrospective case series (2000-2010)	Evaluate the utility of the Alvarado scale in predicting acute appendicitis in adults > 65 years old	Researchers identified pathological reports. Alvarado scores were calculated retrospectively. The score distribution was compared with the original Alvarado cohort (1986).	96	73.7 ± 1.5	2.8 ± 0.8	6.9 ± 0.33	1-4: 3.7%, 5-8: 86.6%, 9-10: 9.7%	ND	ND	100	97.9% (CT)
Konan et al. ¹²	Turkey, 2011	Retrospective case series (date ND)	Evaluate the performance of the Alvarado and Lintula scales in patients > 65 years old	Patients with a pathological diagnosis had their Alvarado and Lintula scores calculated retrospectively. These were compared with a group of patients with non-specific abdominal pain.	41 appendicitis 41 abdominal pain	69	43	ND	ND	ND	ND	100	ND

BMI, body mass index; CT, computed tomography; ND, not described; RIPASA, Raja Isteri Pengiran Anak Saleha Appendicitis.

Table 2. Operational characteristics of the Alvarado scale in patients older than 65 Years

Authors	Scale	Ideal cut-off points	Global ROC (95% CI)	Youden index	Sensitivity (95% CI)	Specificity (95% CI)	PPV	PLR	NLR	Accuracy	Ability to differentiate complicated from uncomplicated appendicitis
Tekyol et al. ¹¹	Alvarado	> 4	0.799 (0.698-0.877)	0.549	69.2 (56.6-80.1)	85.7 (63.7-97.0)	93.7	47.4	4.85	0.36	ND
Deiters et al. ¹³	RIPASA	> 8	0.886 (0.799-0.944)	0.642	78.5 (66.5-87.7)	85.7 (63.7-97.0)	94.4	56.2	5.49	0.25	ND
	Alvarado	ND	ND	ND	ND	ND	ND	ND	ND	ND	Alvarado ≥ 7 Complicated 61.8 Non-complicated 63.2 No differentiation between patients < 70 years, 71-75 years, or > 76 years with complicated and non-complicated appendicitis Alvarado 5-8 correlated more frequently with acute appendicitis, regardless of pathological type. Compared to the original study (1986), differences were found in score distribution between 5-6 (37.8% vs 15%; $p = 0.001$) and 9-10 (9.7% vs 32.1%; $p = 0.001$)
Shchatsko et al. ¹⁴	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	
	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	
Konan et al. ¹²	Alvarado	5	0.969 (0.94-0.998)	ND	87.8	89.7	90.0	87.5	ND	ND	88.7
	Lintula	12	0.928 (0.874-0.982)	ND	87.8	87.2	88	87	ND	ND	87.5

95%CI, 95% confidence interval; ND, not described; RIPASA, Raja Isteri Pengiran Anak Saleha Appendicitis; ROC, Receiver Operating Characteristics; NLR, negative likelihood ratio; PLR, positive likelihood ratio; NPV, negative predictive value; PPV, positive predictive value.

curve value of the Alvarado scale was lower than that of the RIPASA and practically equal to that of the Lintula.

This is the first systematic literature review to offer a clear and structured synthesis of the available information on this topic. Former studies report the acceptable diagnostic performance of the scale in pediatric patients, pregnant women, and the general population, supporting its use in the routine clinical practice^{6,15,16}. Regarding the findings, this review identifies several limitations of the available evidence, which collectively account for the biases of studies published in the past 2 decades, offering opportunities for new studies. Below are some of the most important limitations, as well as some proposals for the research agenda:

- All available primary studies on the diagnostic performance and operational characteristics of the Alvarado scale in older adults are retrospective in design. The validation of diagnostic tests based on retrospective designs represents a threat to the reliability of the results¹⁷. New studies should focus on the prospective validation of the scale.
- The main criterion for the validity of a diagnostic test is its ability to correctly classify whether a patient has the disease (sensitivity) or does not (specificity). It is a common thing to “overestimate” the result of the diagnostic test in studies when the outcome is known beforehand, and test components are assigned to patients accordingly¹⁸. In all the studies included in this review, the Alvarado score was computed retrospectively from data available in health records. Due to the nature of the research design, some clinical findings in the physical examination (for example, Blumberg's sign) can be difficult to assess retrospectively unless adequately recorded in the health history and interpreted as positive. Closely related to the prospective design, it is necessary that in new studies, the calculation of the scale score is performed in real-time based on the clinical findings observed by the examiner.
- In 3 of the 4 studies included in this review, the population consisted of subjects with confirmed acute appendicitis by histopathological study, considered the gold standard. Therefore, these studies have a significant measurement bias related to the exclusion of non-ill subjects, i.e., without acute appendicitis. Consequently, the sensitivity and specificity calculations could be over- or underestimated. Although the reference method

Table 3. Postoperative outcomes and costs

Authors	Surgical Approach	Complications	Mortality	Length of stay	Reoperation	Negative appendectomy (%)	Costs
Tekyol et al. ¹¹	ND	ND	ND	ND	ND	24.4	ND
Deiters et al. ¹³	Laparoscopic: 88.8%	Complicated appendicitis: 37%	1	5.34 ± 5.56	ND	-	ND
	Conversion: 8.8%	Non-complicated appendicitis: 22%	0	3.12 ± 2.86			
Shchatsko et al. ¹⁴	ND	33	1.2	5.88 ± 1.02	5.3	-	ND
Konan et al. ¹²	ND	ND	ND	ND	ND	-	ND

ND, not described.

is crucial in any diagnostic test study, new studies should include patients with acute abdominal pain with and without acute appendicitis. With this type of population, the sensitivity and specificity could be reliable. Furthermore, this type of analysis would allow understanding the behavior of false positives (e.g., what other abdominal pathologies are present in the population). This bias also affects other operational characteristics of the scale; for example, the calculation of the positive likelihood ratio, understood as the ratio between the true positive rate and the false positive rate, and similarly the negative likelihood ratio.

- The studies included in this review poorly report the spectrum of disease severity in the population. The behavior of the scale should be considered in patients with complicated and uncomplicated appendicitis. Although 2 studies report on the severity of appendicitis, they do not report the operational characteristics of the scale in each group. These studies only provide percentages on the scale positivity above certain cut-off points in individuals with different types of appendicitis. A properly designed study should include patients with different severity of appendicitis and report on the operational characteristics in each of them.
- The available comparison of the predictive validity of the Alvarado scale with other scales is limited. Two studies were conducted with the RIPASA and Lintula scales. There are methodological limitations in these studies due to the retrospective calculation of scores. Additionally, the Lintula scale was designed for the pediatric population¹⁹. It is necessary to conduct studies comparing predictive validity against increasingly used and adequately diagnostic-performing scales in adults, such as AIR²⁰, RIPASA²¹,

and Diagnostic Score²². Interestingly, there are no studies evaluating the performance of these latter scales in the geriatric population.

- The above limitations affect the estimation of the optimal cut-off points of the scale, with which the best sensitivity and specificity are obtained. In the included studies, the calculations of these operational characteristics were performed based on the cut-off points of the scale for the general population. Additionally, older adults with suspected acute appendicitis have comorbidity close to 44%, as well as other concomitant abdominal conditions close to 85%, which could affect the cut-off points and the performance of the scale⁵. In practice, these aspects indicate the need to carefully explore the patient and not rely solely on the items of the scale. While the Alvarado scale may be useful in screening, new studies need to dynamically adjust the cut-off points to improve the operational characteristics of the test.
- In 3 studies included in the review, the diagnosis of acute appendicitis was confirmed by imaging modalities. Although the study designs were retrospective and the scale score did not contribute to guiding the request for diagnostic tests, new studies should take this aspect into account.
- Although 2 studies report on morbidity, mortality, and the population length of stay, the impact of the Alvarado scale on these indicators is unknown. New studies should carefully analyze the behavior of the Alvarado scale in reducing morbidity associated with the treatment of acute appendicitis.
- The impact of the Alvarado scale on the direct and indirect costs of clinical care is unknown. New studies should also consider this aspect.

- The available studies included in this review were conducted in the United States and Turkey. The performance of the scale in other clinical settings (e.g., Europe and Latin America) is unknown.

Conclusions

Acute abdominal pain is a diagnostic challenge in the elderly. According to the above-mentioned aspects, and despite some limitations inherent to systematic literature reviews related to the quantity and quality of studies, as well as the lack of evaluation of grey literature, the Alvarado scale has limited usefulness in this population. A high prevalence of conditions that confuse the diagnosis in these patients, a greater possibility of a modified inflammatory response (chronic medication intake, frailty condition, etc.), and the relevance of performing high diagnostic performance tests for other intra-abdominal inflammatory conditions (CT scan or MRI)^{23,24} limit the usefulness of the Alvarado scale as a determining diagnostic element for surgical or expectant management. This systematic review of the literature identifies some knowledge gaps related to this topic and contributes some proposals for future research.

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Conflicts of interest

None declared.

Ethical disclosures

Protection of human and animal subjects. The authors declare that no experiments were performed on humans or animals for this study.

Confidentiality of data. The authors declare that no patient data appear in this article.

Right to privacy and informed consent. The authors declare that no patient data appear in this article.

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