The role of Alvarado and Ohmann scoring systems in diagnosing appendicitis and assessing disease severity

Muzaffer Önder Öner,[1] Fırat Aslan,[2] Gökalp Okut[3]

[1]Department of General Surgery, Izmir University of Economics, Izmir, Türkiye
[2]Department of General Surgery, Van Yuzuncu Yıl University Faculty of Medicine, Van, Türkiye
[3]İzmir City Hospital General Surgery Clinic, Izmir, Türkiye

ABSTRACT

Introduction: Acute appendicitis is among the most common causes of acute abdomen. While diagnosis is generally straightforward, it may be challenging to differentiate from other conditions, particularly in pregnant women and the elderly. Currently, several scoring systems have been developed to aid in diagnosis. This study aims to evaluate the significance of these scoring systems in diagnosing appendicitis and assessing the severity of inflammation.

Materials and Methods: A total of 210 patients hospitalized between 01/01/2016 and 01/06/2019 at the General Surgery Clinic of the Republic of Türkiye S.B.U Van Training and Research Hospital for acute appendicitis were examined retrospectively. Appendectomy was performed following ultrasonography for patients evaluated using the Alvarado and Ohmann scoring systems, and these scores were compared with intraoperative severity scores. The predictive value of the Alvarado and Ohmann scoring systems in diagnosing acute appendicitis was analysed.

Results: A moderate positive correlation was identified between the Alvarado and Ohmann scores (r=0.508; p<0.001). The Alvarado score demonstrated a statistically significant accuracy in predicting acute appendicitis diagnosis based on histopathological findings (p=0.027), whereas the Ohmann score did not show statistical significance (p=0.807). Although both scores correlated weakly with intraoperative inflammation grading, a significant association was found between the Alvarado scoring system and intraoperative severity grading (r=0.30; p=0.002). No significant correlation was observed between the Ohmann score and intraoperative severity grading (r=0.09; p=0.384).

Conclusion: The Alvarado scoring system proved valuable in predicting appendicitis, while the Ohmann scoring system was more useful in suggesting the exclusion of appendicitis.

Keywords: Alvarado, appendicitis, inflammation, Ohmann

Introduction

Acute appendicitis is one of the most frequent causes of acute abdomen. With timely and accurate diagnosis, acute append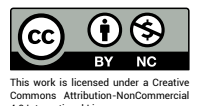icitis (AA) generally has low mortality and morbidity. However, delayed intervention can lead to progression from simple appendicitis to perforation. Historically, AA diagnoses based solely on physical examination and symptoms have led to perforation rates of around 20%

and negative appendectomy (NA) rates ranging from 2% to 30%, both of which are relatively high. Extending the preoperative observation period can potentially reduce negative laparotomy rates; however, prolonged waiting also risks perforation, thereby increasing morbidity and mortality.[1,2] In recent years, various scoring systems have been implemented in clinical practice to support the early diagnosis and treatment of acute appendicitis. Among the most commonly utilized systems in daily practice are the Alvarado, Ohmann, Eskelinen, and Lintula scores. The application of these scoring systems helps reduce negative laparotomy rates and the risk of increased perforation rates associated with prolonged observation and hospital stay in patients without acute appendicitis.[3-5] Among these, the scoring system developed by Alvarado is the most widely recognized and utilized.[6,7] This system relies on symptoms, clinical findings, and laboratory results to guide surgical decision-making. The Alvarado scoring system, specifically developed for diagnosing acute appendicitis, is based on clinical indicators and leukocyte count, with a maximum score of 10 (Table 1). The Ohmann score is another scoring system that can be easily applied to diagnose appendicitis in patients presenting with abdominal pain (Table 2).[8] This study aims to evaluate the effectiveness of these two scoring systems in patients diagnosed with acute appendicitis and to provide a cost-effective diagnostic tool, particularly for physicians in peripheral healthcare settings.

Materials and Methods

This retrospective study examined 210 patients who were hospitalized with acute appendicitis between 01/01/2016 and 01/06/2019 at the General Surgery Clinic of the Repub-

Table 1. Alvarado scoring

Feature	Score when present
Migration of pain	1
Anorexia	1
Nausea	1
Tenderness in right lower quadrant	2
Rebound pain	1
Elevated temperature	1
Leukocytosis	2
Shift of white blood cell count to left	1
Total (maximum)	10

Table 2. Ohman scoring

Parameter	Result
Tenderness in right lower quadrant	4.5 points
Rebound tenderness, contralateral	2.5 points
Dysuria	2.0 points
Constant pain	2.0 points
White blood cell >10,000/mL	1.5 points
Patient aged >50 years	1.5 points
Local guarding	1.0 point
Shifting pain	1.0 point
Total <6.5	Acute appendicitis unlikely

lic of Türkiye S.B.U Van Training and Research Hospital. Ethical approval for the study was granted by the Ethics Committee of the same institution (Consent No. 2019/16) on 22/08/2019. The study was conducted in accordance with the principles of the Declaration of Helsinki. The Alvarado and Ohmann scores were calculated for all patients presenting with abdominal pain who subsequently underwent appendectomy at the clinic (Tables 1 and 2). All patients underwent physical examination, laboratory testing, and radiological imaging (USG and CT). Informed consent for surgery was obtained from each patient. Pathology results from all operated patients were analyzed to assess the accuracy of the scoring systems. Patients with an Ohmann score between 6.5 and 12 and an Alvarado score below 7 were placed under clinical observation and were given medical treatment. Patients who declined surgery, had an inconclusive diagnosis of acute appendicitis, or whose symptoms regressed with medical management alone were excluded from the study. The Ohmann scoring system comprises a total of 8 parameters. Patients with a cumulative score of 12 or above are considered to have a high likelihood of acute appendicitis, and surgical intervention is recommended. Scores between 6.5 and 12 place patients in a 'suspicious' category, for which clinical follow-up is advised. For those scoring 6.5 or below, an acute appendicitis diagnosis is generally ruled out.[5] The Alvarado scoring system, which consists of 8 parameters, has a confidence interval of 78-82%.[6,9] Surgical intervention is recommended for patients with an Alvarado score of 7 or higher, while clinical follow-up is advised for those with a score below 7.[10] In this study, the Mann-

Table 3. Intraoperative severity scoring

Major finding	Points
Negative appendectomy	0
Increased vascularity	1
Perforated appendix	2
Perforated appendix + phlegmonous appendicitis	3

heim Peritonitis Index (MPI) was used intraoperatively to assess the severity of peritonitis (Table 3). While the MPI is not specific to acute appendicitis, it is a widely used scoring system for evaluating peritonitis severity.[11] In the intraoperative peritonitis scoring system, findings such as negative laparotomy, increased vascularity, perforation, and phlegmonous appendicitis were evaluated macroscopically. This study aims to diagnose acute appendicitis using the Mannheim scoring intraoperatively and to determine the degree of correlation between inflammation severity and the Alvarado and Ohmann scoring systems.

Statistical Analysis

Continuous and categorical data were analyzed using SPSS software (Version 20.0, IBM, Armonk, NY, USA). Descriptive statistics for categorical data are presented as frequencies and percentages, while continuous data are expressed as mean±standard deviation, minimum-maximum, and median values according to their distribution. Since the Alvarado and Ohmann scores were not normally distributed (Kolmogorov-Smirnov test), these variables, along with ordered variables from the intraoperative severity scoring, were compared using the Kruskal-Wallis test. Potential predictors identified in previous analyses were included in the multivariate analysis, and logistic regression was performed to determine independent predictors based on pathology results. Agreement between pathology and USG results was assessed using Kappa statistics. A Type I error rate of less than 5% was considered statistically significant.

Results

The study included a total of 210 patients, with 50.48% (n=106) being female and 49.52% (n=104) male. Standard laparoscopic appendectomy was performed in 128 patients (60.9%), while open appendectomy via McBurney's incision was performed in 82 patients (39.1%). The overall mean age of patients was 33 years, with a mean age of 30

years for female patients and 36 years for male patients.

A statistically significant correlation was observed between the Alvarado and Ohmann scores (r=0.508; p<0.001). Based on histopathological results, the Alvarado scoring system was statistically significant for patients diagnosed with appendicitis (p=0.027), whereas the Ohmann scoring system did not show statistical significance (p=0.807).

When white blood cell (WBC) counts were evaluated based on scoring system results, a statistically significant difference was observed for the Alvarado score (p=0.004), whereas the Ohmann score did not show statistical significance (p=0.834) (Fig. 1 and 2).

Intraoperative Peritonitis Severity Scoring

In examining the correlation between the Alvarado and Ohmann scoring systems and intraoperative peritonitis severity, a statistically significant correlation was found with the Alvarado score (p=0.002), while no significant correlation was observed with the Ohmann score
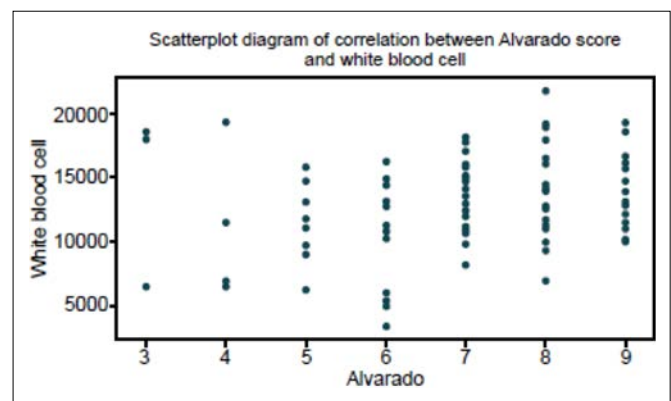
Figure 1. Relationship between Alvarado score and white blood cell count.
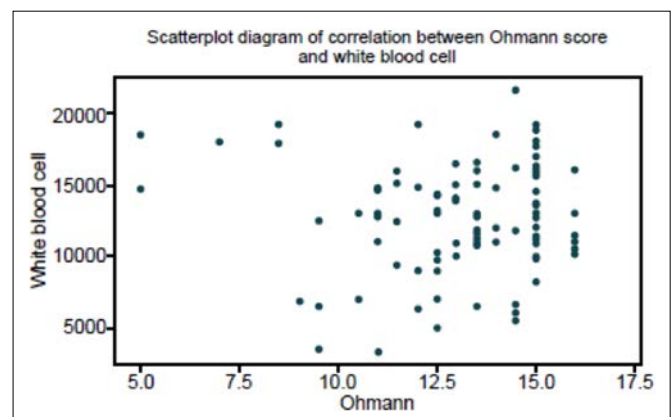
Figure 2. Relationship between Ohmann score and white blood cell count.

(p=0.384). When patients were grouped by intraoperative peritonitis scores, those with scores of 0–3 showed a statistically significant association with the Alvarado score (p=0.016). The Alvarado score was 7 for patients with intraoperative peritonitis scores of 0, 1, or 2, and also 7 for those with a score of 3. In contrast, no statistically significant association was found between the Ohmann score and these four peritonitis severity groups (p=0.547).

Reliability of Ultrasonography

Ultrasonography (USG) demonstrated a specificity of 92.86% and a sensitivity of 80.22% in relation to histopathology results. The consistency of USG with final histopathology findings was 48.3%.

Discussion

Acute appendicitis is one of the leading causes of acute abdominal pain. Preoperative diagnosis is particularly challenging in premenopausal and elderly female patients, as gynecological and genitourinary pathologies often present with similar clinical symptoms, leading to potential confusion with appendicitis.[12,13] Delayed diagnosis may lead to perforation and sepsis, increasing both mortality and morbidity. Additionally, the literature reports negative laparotomy rates ranging from 10% to 40%.[14,15] Despite the availability of advanced imaging methods like USG and CT, scoring systems such as Alvarado and Ohmann have been developed to help reduce negative laparotomy rates. This study examines the correlation between intraoperative peritonitis severity scoring and the Alvarado and Ohmann scoring systems.

The Alvarado scoring system has demonstrated high specificity and sensitivity, establishing it as a straightforward and effective diagnostic tool.[9,16] Numerous studies have been conducted to improve the accuracy of acute appendicitis diagnosis.[17] Clinical scoring systems have been developed to reduce the number of patients requiring surgical intervention and to distinguish between delayed and uncomplicated appendicitis.[6] In their study, Kariman et al. demonstrated that inflammation severity increases in parallel with higher Alvarado scores.[18] Among patients presenting to the clinic with acute abdominal pain, the rate of acute appendicitis diagnosis was 93% for those with an Alvarado score of 7 or higher, compared to 26% for those with a score below 7. Our findings align with the literature, showing that the Alvarado score is statistically significant in diagnosing acute appendicitis (p=0.027).

The Mannheim Peritonitis Index, as it is not specific to appendicitis, was not utilized in this study.[11] In this study, a simple intraoperative peritonitis severity scoring method was employed to macroscopically assess the intensity of inflammation. This scoring system categorizes peritonitis severity into four groups: minimal changes, limited necrosis without perforation, peritonitis with perforation, and limited peritonitis.[12] Dumlu et al. reported that, despite achieving statistical significance, no strong correlation was found with the peritonitis severity score.[17] In our study, patients were assigned scores of 0, 1, 2, or 3 based on laparotomy findings. A score of 0 was given to patients without appendicitis, 1 to those with increased vascularity, 2 to those with perforation, and 3 to those with phlegmonous findings. These scores were found to be statistically significant when compared with the Alvarado score.

The Ohmann scoring system is a straightforward tool used in diagnosing acute appendicitis. In a study conducted by Zielke et al., the Ohmann scoring system was shown to be effective in supporting the diagnosis of acute appendicitis.[19] In our study, a statistically significant difference was observed when comparing the Alvarado and Ohmann scores. However, when evaluated against histopathological data, the Ohmann score did not reach statistical significance (p=0.807). In another study, the Ohmann score was found to be more effective in excluding the diagnosis of appendicitis.[20] In our study, no statistically significant correlation was observed between the intraoperative severity score and WBC count (p=0.384). We suggest that a low Ohmann score may help exclude the diagnosis of appendicitis, whereas a high Ohmann score may indicate the need for further diagnostic evaluation.

WBC counts were evaluated in relation to the scoring systems, a statistically significant association was observed with the Alvarado score, whereas no significant association was found with the Ohmann score. These findings are consistent with those reported in the literature.[6,19]

Yılmaz et al., aimed to evaluate 2 of the current scoring systems with respect to accurate diagnosis of the disease and indication of inflammation severity. A total of 105 patients diagnosed with acute appendicitis were included in the study. Subsequent to Alvarado and Ohmann scoring, ultrasonography image was obtained and appendectomy was performed. A unique intraoperative severity scoring system was used to measure severity of inflammation and to compare Alvarado and Ohmann scoring system results to assess accuracy of predictive value for acute appendici-

tis. Moderate positive correlation was found between Alvarado score and Ohmann score (r=0.508; p<0.001). Rate of Alvarado score successfully predicting diagnosis of acute appendicitis based on histopathological results was statistically significant (p=0.027), while rate of Ohmann score was not statistically significant (p=0.807). Correlation between both scores and grading of inflammation performed during the operation was weak, but statistical significance was observed between Alvarado scoring system and intraoperative severity scoring (r=0.30; p=0.002). No statistical difference was observed between Ohmann scoring and intraoperative severity scoring (r=0.09; p=0.384). In conclusion, Alvarado score is better able to predict acute appendicitis and provide an idea of severity of inflammation. Ohmann score is more useful to provide guidance and eliminate acute appendicitis from consideration when conditions are more uncertain and obscured.[21,22]

In our study, ultrasonography (USG) demonstrated a specificity of 92.86% and a sensitivity of 80.22% when compared to histopathology results. The concordance of USG with final histopathological findings was found to be 48.3%. This may be attributed to the subjective nature of both ultrasonographic and pathological evaluations. Our findings are consistent with the data reported in the literature.[23]

We also believe that there is no significant correlation between the Ohmann score and the severity of inflammation. In cases where appendicitis cannot be definitively diagnosed, additional scoring systems may aid in clarifying the diagnosis. The Alvarado scoring system is a reliable tool for appendicitis, as it provides information on the severity of inflammation and is simple and easy to apply. Numerous studies have shown that the Ohmann scoring system is more effective for excluding acute appendicitis than for confirming the diagnosis.[19] As our study is a single-center study, we believe that further multi-center, prospective studies with larger patient populations are needed.

Disclosures

Ethics Committee Approval: Ethical approval for the study was granted by the Ethics Committee of the S.B.U Van Training and Research Hospital (No. 2019/16, Date: 22/08/2019).

Peer-review: Externally peer-reviewed.

Conflict of Interest: The authors declare no potential conflict of interests with respect to the research, authorship, and/or publication of this article.

Financial Disclosure: The authors received no financial support for the research, authorship, and/or publication of this article.

Authorship Contributions: Concept: M.Ö.Ö.; Design: M.Ö.Ö., F.A.; Supervision: M.Ö.Ö., F.A.; Resources: M.Ö.Ö., F.A.; Materials: G.O.; Data Collection and/or Processing: M.Ö.Ö., G.O., F.A.; Analysis and/or Interpretation: M.Ö.Ö.; Writing Manuscript: M.Ö.Ö., F.A., G.O.; Critical Review: M.Ö.Ö., F.A.

References

1. Andersson RE. Meta-analysis of the clinical and laboratory diagnosis of appendicitis. Br J Surg 2004;91(1):28–37.
2. Hoffmann J, Rasmussen OO. Aids in the diagnosis of acute appendicitis. Br J Surg 1989;76(8):774–9.
3. Bonadio W, Brazg J, Telt N, Pe M, Doss F, Dancy L, et al. Impact of In-hospital timing to appendectomy on perforation rates in children with appendicitis. J Emerg Med 2015;49(5):597–604.
4. Eskelinen M, Ikonen J, Lipponen P. A computer-based diagnostic score to aid in diagnosis of acute appendicitis: A prospective study of 1333 patients with acute abdominal pain. Theor Surg 1992;7:86–90.
5. Ohmann C, Franke C, Yang Q, Margulies M, Chan M, van Elk PJ, et al. Diagnosescore für akute Appendicitis [Diagnostic score for acute appendicitis]. Chirurg 1995;66(2):135–141. [Article in German].
6. Alvarado A. A practical score for the early diagnosis of acute appendicitis. Ann Emerg Med 1986;15(5):557–64.
7. Sousa-Rodrigues CF, Rocha AC, Rodrigues AK, Barbosa FT, Ramos FW, Valões SH. Correlation between the Alvarado Scale and the macroscopic aspect of the appendix in patients with appendicitis. Rev Col Bras Cir 2014;41(5):336–9.
8. Kıyak G, Korukluoğlu B, Özgün Y, Devay AÖ, Kuşdemir A. Evaluation of Ohmann and Eskelinen scores, leukocyte count and ultrasonography findings for diagnosis of appendicitis. Ulus Travma Acil Cerrahi Derg 2009;15:77–81.
9. Nirajlal B, Gabriel R, Anand R, Sohil AK. Evaluation of Alvarado score in acute appendicitis: A prospective study. The Internet Journal of Surgery. 2007;9:10672.
10. İnan M, Tulay SH, Besim H, Karakaya J. The value of ultrasonography and its comparison with Alvarado scoring system in acute appendicitis. Ulusal Cerrahi Derg 2011;27:149–53.
11. Bosscha K, Reijnders K, Hulstaert PF, Algra A, van der Werken C. Prognostic scoring systems to predict outcome in peritonitis and intra-abdominal sepsis. Br J Surg 1997;84(11):1532–4.
12. Antevil J, Rivera L, Langenberg B, Brown CV. The influence of age and gender on the utility of computed tomography to diagnose acute appendicitis. Am Surg 2004;70(10):850–3.
13. N N, Mohammed A, Shanbhag V, Ashfaque K, S A P. A

Comparative study of RIPASA score and ALVARADO core in the diagnosis of acute appendicitis. J Clin Diagn Res 2014;8(11):NC03−5.

14. Toorenvliet BR, Wiersma F, Bakker RF, Merkus JW, Breslau PJ, Hamming JF. Routine ultrasound and limited computed tomography for the diagnosis of acute appendicitis. World J Surg 2010;34(10):2278−85.

15. Kalan M, Talbot D, Cunliffe WJ, Rich AJ. Evaluation of the modified Alvarado score in the diagnosis of acute appendicitis: A prospective study. Ann R Coll Surg Engl 1994;76(6):418−9.

16. Owen TD, Williams H, Stiff G, Jenkinson LR, Rees BI. Evaluation of the Alvarado score in acute appendicitis. J R Soc Med 1992;85(2):87−8.

17. Dumlu EG, Tokaç M, Bozkurt B, Yildirim MB, Ergin M, Yalçin A, et al. Correlation between the serum and tissue levels of oxidative stress markers and the extent of inflammation in acute appendicitis. Clinics (Sao Paulo) 2014;69(10):677−82.

18. Kariman H, Shojaee M, Sabzghabaei A, Khatamian R, Derakhshanfar H, Hatamabadi H. Evaluation of the Alvarado score in acute abdominal pain. Ulus Travma Acil Cerrahi Derg 2014;20(2):86−90.

19. Zielke A, Sitter H, Rampp TA, Schäfer E, Hasse C, Lorenz W, et al. Uberprüfung eines diagnostischen Scoresystems (Ohmann-Score) für die akute Appendicitis [Validation of a diagnostic scoring system (Ohmann score) in acute appendicitis]. Chirurg 1999;70(7):777−84. [Article in German]

20. Zielke A, Sitter H, Rampp T, Bohrer T, Rothmund M. Clinical decision-making, ultrasonography, and scores for evaluation of suspected acute appendicitis. World J Surg 2001;25(5):578−84.

21. Yılmaz EM, Kapçı M, Çelik S, Manoğlu B, Avcil M, Karacan E, et al. Should Alvarado and Ohmann scores be real indicators for diagnosis of appendicitis and severity of inflammation? Ulus Travma Acil Cerrahi Derg 2017;23(1):29−33.

22. Köse E, Hasbahçeci M, Aydın MC, Toy C, Saydam T, Özsoy A, et al. Is it beneficial to use clinical scoring systems for acute appendicitis in adults? Ulus Travma Acil Cerrahi Derg 2019;25(1): 12−9.

23. Dikicier E, Altıntoprak F, Çakmak G, Değirmenci B, Akbulut G. Akut apandisit tanısında ultrasonografinin yeri. Sakarya Tıp Derg 2011;1(2):64−6.