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ORIGINAL ARTICLE

Does Scoring System Help Us in the Diagnosis of Acute Appendicitis? A Prospective Clinical Trial

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Abstract

It is very important to make accurate and early diagnosis to reduce both the rate of negative laparotomy and the morbidity and mortality associated with acute appendicitis. Numerous scoring systems have been described in the diagnosis of acute appendicitis. We aimed to determine the accuracy rates of these scoring systems in the diagnosis of acute appendicitis by applying Alvarado, Eskelinen, and Ohmann clinical scoring systems to patients who underwent appendectomy. This study was performed on patients who underwent appendectomy for acute appendicitis at Başkent University Alanya Hospital and Alanya Alaaddin Keykubat University Education and Research Hospital between September 2017 and December 2018. The sensitivity and specificity of Alvarado, Eskelinen, and Ohmann scoring systems as well as the compatibility analysis of scoring systems with pathology results were investigated. A total of 554 patients undergoing appendectomy were included in the study. The sensitivity of Eskelinen scoring method was found to be 53.4%, the specificity was 68.1%; the sensitivity of Alvarado scoring method 41.6%, the specificity 79.7%; and the sensitivity of Ohmann scoring system 94.0%, the specificity was 8.7%. In conclusion, Ohmann scoring system has the highest sensitivity; it could be more efficient in exclusion of the appendicitis diagnosis due to its low specificity. It is also concluded that some clinical parameters that are scored in Eskelinen and Alvarado scoring systems may decrease the sensitivity and specificity of these methods depending on the patient population and atypical clinical presentations.

Keywords Acute appendicitis · Diagnosis · Scoring system · Alvarado · Eskelinen · Ohmann

Introduction

Acute appendicitis (AA) is the most common surgical disease that requires surgery in patients admitted with acute abdominal pain in general surgery outpatient clinics, with a lifetime prevalence of 8.6% in men and 6.7% in women [1]. The rate of negative laparotomy varies between 15 and 30% in patients who were operated with the preliminary diagnosis of AA, and the rate of perforation is observed to be as high as 20% [2]. Therefore, it is very important to make accurate and early diagnosis to reduce both the rate of negative laparotomy and the morbidity and mortality associated with AA. Surgery decision is usually made with the results of physical examination and laboratory tests. Although clinical presentation and physical examination are very valuable and important in the diagnosis of AA, clinical scoring systems and radiological examination modalities such as ultrasound and tomography are also needed because the disease can manifest atypical clinical presentation and can often be confused with many other diseases in the differential diagnosis [3].

Although new technological developments are frequently used for diagnostic purposes, the rates of correct diagnosis vary. Despite the common usage of radiological imaging and laboratory tests in routine practice, the diagnosis of AA is mainly based on a careful history and physical examination. [2] Numerous scoring systems have been described in the diagnosis of AA as a result of many clinical studies aimed at the development of procedures that provide the most effective and noninvasive diagnosis of AA [4]. The aim of using these scoring systems is to reduce the rates of negative laparotomy and perforated

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appendicitis by achieving the correct diagnosis in the most practical way. Eskelinen, Alvarado, and Ohmann scoring systems are important scoring systems and have been frequently used in the diagnosis of AA [5–7].

In our study, we aimed to determine the accuracy rates of these scoring systems in the diagnosis of AA by applying Alvarado, Eskelinen, and Ohmann clinical scoring systems to patients who underwent appendectomy.

Methods

This study was performed on patients who underwent appendectomy for AA at Başkent University, Alanya Hospital and Alanya Alaaddin Keykubat University, Education and Research Hospital between September 2017 and December 2018. All patients over 16 years of age were included in the study. The patient's age, gender, height, weight, demographic data, laboratory test results along with history, and physical examination findings used in the scoring methods were recorded. All the 3 scoring methods were applied in parallel, and the sensitivity was calculated as true positives of operative finding/histopathology of appendicitis. In Eskelinen scoring system, history of right lower quadrant pain, presence of pain lasting less than or over 48 h, presence of rebound tenderness on right lower in physical examination, presence of leukocytosis in laboratory findings were scored; a score below 48 points was considered low risk for appendicitis, a score between 48 and 57 was considered suspected appendicitis (to be monitored), and a score over 57 points was considered the most likely appendicitis [5, 8]. In Alvarado scoring system, patients were scored with regard to floating right lower quadrant pain, loss of appetite, nausea and vomiting, sensitivity in the right lower quadrant in the physical examination, presence of rebound tenderness or temperature rise, presence of leukocytosis, and neutrophil left shift in laboratory findings. A total score of 4 or less was considered low risk for appendicitis, a score between 4 and 7 was considered suspected appendicitis (to be monitored), and a score above 7 was considered the most likely appendicitis [2, 6]. In Ohmann scoring system, patients under the age of 50, presence of pain in the right lower quadrant, unremitting nature of pain, presence of urinary complaints, presence of rebound tenderness on right lower quadrant in physical examination, and leukocytosis in laboratory findings were taken into account. A total score below 6 was considered low risk for appendicitis, a score between 6 and 11.5 was considered suspected appendicitis (to be monitored), and a score of 12 and above was considered the most likely appendicitis [7, 8]. Postoperative pathology results were compared with the results obtained from the scoring methods and diagnostic accuracy rates were evaluated. Scoring methods and points of the patients are shown in Table 1. Abdominal ultrasonography was performed routinely in all patients and abdominal tomography was performed in patients whose appendix/appendicitis could not be visualized or could not be diagnosed by ultrasonography.

Statistical Methods

Mean, standard deviation, median lowest, median highest, frequency, and ratio values were used in descriptive statistics of the data. Kappa compliance test was used in compliance analysis. SPSS 22.0 program was used for the statistical analysis.

Ethical Approval

This study was approved by the Ethics Committee of Alanya Alaaddin Keykubat University of Medical Sciences, and all of the subjects' parents were informed regarding the details of the study, and they signed a consent form.

Results

A total of 676 patients undergoing appendectomy were included in the study. One hundred and twenty-two patients were excluded from the study due to lack of necessary information for the scoring systems we intended to evaluate. Statistical evaluation was performed on a total of 554 patients. The gender distribution of the patients was 185 (33.4%) women and 369 (66.6%) men; the mean age was 30 years (16–90). In pathological examination, 485 (87.5%) patients were diagnosed with AA; however, pathology revealed no AA in 17.2% (32/185) of female patients and 10.0% (37/369) of male patients (12.5% (69) of all patients). Pathological diagnosis of perforated appendicitis was made in 39 patients (7%). "Most likely appendicitis" was predicted in 281 (50.7%) patients by Eskelinen, in 216 (39.0%) patients by Alvarado, and in 519 (93.7%) patients by Ohmann scoring system. In Table 2, demographic characteristics of patients, pathologic examination results, and appendicitis diagnosis ratios according to scoring systems were given.

Pathologic diagnosis confirmed appendicitis in 259 of 281 patients diagnosed with appendicitis using Eskelinen method, and there was a significant correlation between pathology results and Eskelinen method. (Kappa = 0.095/p = 0.001). Of the 273 patients who were not diagnosed with appendicitis, 226 had a pathologic diagnosis of appendicitis. With these results, the sensitivity of Eskelinen method was found to be 53.4%, the positive predictive value (PPV) was 92.2%, the specificity was 68.1%, and the negative predictive value (NPV) was 17.2%. Pathologic diagnosis confirmed appendicitis in 202 of 216 patients diagnosed with appendicitis using Alvarado method, and there was a significant correlation between pathology results and Alvarado method (Kappa =

Table 1 Scoring systems and points used in the diagnosis of acute appendicitis

Symptom	Eskelinen		Alvarado	Ohmann	
	Yes	No	Yes	Yes	No
Anamnez					
Age 50 <				1.5 points	
Floating lower quadrant pain			1 point		
Right lower quadrant pain	2 × 3.51 points			1 point	
Duration of pain 48 h<	2 × 2.18 points				
Unremitting nature of pain				2 points	
Urinary complaint					2 points
Loss of appetite			1 point		
Nausea–vomiting			1 point		
Physical examination					
Right lower quadrant tenderness	2 × 11.41 points		2 points	4.5 points	
Abdominal guarding	2 × 6.62 points		1 point	1 point	
Rebound tenderness	2 × 4.25 points			2.5 points	
Increase in temperature			1 point		
Laboratory tests					
Leukocytosis (10,000 >)	2 × 5.58 points		2 points	1.5 points	
Neutrophil left shift			1 point		
Total score	48 <, low risk		4 <, low risk	6 <, low risk	
	48–56, suspected (monitoring)		5–6, suspected (monitoring)	4–11.5, suspected (monitoring)	
	57 ≥, appendicitis		7 >, appendicitis	12 ≥, appendicitis	

0.080/$p = 0.001$). Of the 338 patients who were not diagnosed with appendicitis, 283 had a pathologic diagnosis of appendicitis. The sensitivity of Alvarado scoring method was found to be 41.6%, the PPV was 93.5%, the specificity was 79.7%, and the NPV was 16.3%. Pathologic diagnosis confirmed appendicitis in 456 of 519 patients diagnosed with appendicitis using Ohmann method, and there was a significant correlation between pathology results and Ohmann score (Kappa = 0.034/$p = 0.386$). Of the 35 patients who were not diagnosed with appendicitis, 29 had a pathologic diagnosis of appendicitis. With these results, the sensitivity of Ohmann scoring method was 94.0%, the PPV was 87.9%, the specificity was 8.7%, and the NPV was 17.1%. In perforated appendicitis, the sensitivity of Eskelinen, Alvarado, and Ohmann scoring systems was 17.9%, 43.6%, and 100%, respectively; the PPV were 2.5%, 7.9%, and 7.5%, respectively; specificity was 46.8, 93.5%, and 6.8%, respectively; and the NPV were 88.3%, 93.5%, and 100.0%, respectively. The sensitivity, specificity, positive, and negative predictive values obtained by scoring systems are shown in Table 3.

Table 2 Demographic characteristics of patients; appendicitis rates according to pathology and scoring system

		Min max	Median	Mean ± SD/*n* (%)	
Age		16–90	30.0	32.8	± 14.2
Age	16–30			270	48.7%
	31–40			129	23.3%
	41–50			78	14.1%
	? 50			77	13.9%
Sex	Female			185	33.4%
	Male			369	66.6%
Pathology	(−)			69	12.5%
	(+)			485	87.5%
Eskelinen	(−)			273	49.3%
	(+)			281	50.7%
Alvarado	(−)			338	61.0%
	(+)			216	39.0%
Ohman	(−)			35	6.3%
	(+)			519	93.7%
Perforated appendicitis	(−)			515	93.0%
	(+)			39	7.0%

In the analysis of the efficacy of scoring systems according to the gender of the patients, there was a significant correlation between Eskelinen score and pathology results in women (Kappa = 0.151/$p = 0.010$), while there was no significant correlation in men (Kappa = 0.050/$p = 0.082$). In Eskelinen method, the sensitivity was found to be 51.0% in women, 54.4% in men, and the specificity in women was 71.4%, 63.0% in men. While there was a significant correlation

Table 3 The sensitivity, specificity, positive, and negative predictive values of scoring systems

		Pathology (appendicitis)		Sensitivity	PPV	Specificity	NPV	Kappa	*p*
		(−)	(+)						
Eskelinen	(−)	47	226	53.4%	92.2%	68.1%	17.2%	0.095	*0.001*
	(+)	22	259						
Alvarado	(−)	55	283	41.6%	93.5%	79.7%	16.3%	0.080	*0.001*
	(+)	14	202						
Ohman	(−)	6	29	94.0%	87.9%	8.7%	17.1%	0.034	0.386
	(+)	63	456						
		Perforated appendicitis		Sensitivity	PPV	Specificity	NPV	Kappa	*p*
		(−)	(+)						
Eskelinen	(−)	241	32	17.9%	2.5%	46.8%	88.3%	− 0.091	*0.000*
	(+)	274	7						
Alvarado	(−)	316	22	43.6%	7.9%	61.4%	93.5%	0.016	0.541
	(+)	199	17						
Ohman	(−)	35	0	100.0%	7.5%	6.8%	100.0%	0.010	0.093
	(+)	480	39						
Kappa test									

between Alvarado score and pathology results in women (Kappa = 0.199/p = 0.000), there was no significant correlation in men (Kappa = 0.036/p = 0.096). In Alvarado method, the sensitivity was found to be 49.7% in women, 38.3% in men, the specificity was 81.0% in women, 77.8% in men. No significant correlation was found between the Ohmann score and pathology results in men and women (Kappa = 0.037/p = 0.586 in women, Kappa = 0.050/p = 0.302 in men). The sensitivity of Ohmann method in women was 88.8% and 96.2% in men; the specificity in women was 14.3% in women and 0.0% in men. The sensitivity, specificity, PPV, and NPV of the scoring systems according to gender are shown in Table 4. In the analysis of the concordance/discordance rates between scoring systems, significant correlation was found for all scoring systems ($p < 0.05$). The concordance/discordance values are shown at Table 5.

Discussion

The most crucial result of delay in diagnosis of AA is the increase in the rate of perforated appendicitis. Negative appendectomy can cause morbidity and mortality as well as unnecessary labor and economic loss [9]. Ultrasonography has high

Table 4 The sensitivity, specificity, positive, and negative predictive values of scoring systems according to gender

		Pathology		Sensitivity	PPV	Specificity	NPV	Kappa	*p*
		(−)	(+)						
Female									
Eskelinen	(−)	30	70	51.0%	85.9%	71.4%	30.0%	0.151	*0.010*
	(+)	12	73						
Alvarado	(−)	34	72	49.7%	89.9%	81.0%	32.1%	0.199	*0.000*
	(+)	8	71						
Ohman	(−)	6	16	88.8%	77.9%	14.3%	27.3%	0.037	0.586
	(+)	36	127						
Male									
Eskelinen	(−)	17	156	54.4%	94.9%	63.0%	9.8%	0.050	0.082
	(+)	10	186						
Alvarado	(−)	21	211	38.3%	95.6%	77.8%	9.1%	0.036	0.096
	(+)	6	131						
Ohman	(−)	0	13	96.2%	92.4%	0.0%	0.0%	0.036	0.302
	(+)	27	329						
Kappa test									

Table 5 The concordance/discordance values between scoring systems

		Ohman (−)	Ohman (+)	Concordance	Discordance	Kappa	*p*
Eskelinen	(−)	35	238	57.0%	43.0%	0.130	*0.000*
	(+)	0	281				
Alvarado	(−)	32	306	44.2%	55.8%	0.064	*0.000*
	(+)	3	213				
		Alvarado (−)	Alvarado (+)	Concordance	Discordance	Kappa	*p*
Eskelinen	(−)	241	32	76.7%	23.3%	0.536	*0.000*
	(+)	97	184				

Kappa test

accuracy rates in expert hands, but different rates of accuracy have been reported from many centers because of individual-dependent nature of the procedure [10, 11]. Tomography has significantly reduced the negative appendectomy rates; however, it is not available in every center for 24 h. Furthermore, scoring systems such as Lintula, Ohmann, Eskelinen, Fenyö-Lindberg, and Alvarado have been developed because radiological examinations cause delays in diagnosis, increase cost, and most importantly, do not increase accuracy rates to desired levels. The common point of these scoring systems is that they are practical, non-invasive, and require no expertise due to the easy evaluation [4]. There may be discrepancies between scoring points and results even in the same patient group or selected patient populations. Moreover, the differences in the clinical patterns and the incidence of acute abdominal pain varying among geographic regions may limit the usability and sensitivity of these scoring systems [12].

The two most important goals in the use of scoring systems are to reduce the rate of negative laparotomies and perforated appendicitis. As a result of previous studies, rates which can be accepted as a high-quality diagnostic criterion are reported as follows: negative appendectomy rate 15%, negative laparotomy rate 10%, potential perforation rate 35%, overlooked perforation rate 15%, and overlooked appendicitis rate 5% [13, 14]. The rate of perforation prevention of surgeons who advocate for early intervention in suspected cases is 20–40% and the rate of negative appendectomy is generally between 15 and 20% [15]. In our study, 485 (87.5%) of 554 patients operated for AA were diagnosed as AA as a result of pathology examination. The rate of negative appendectomies was 17.5% (32/185) in women and 10.0% (37/369) in men. A total of 39 patients (7%) were diagnosed as perforated appendicitis in pathology examination.

It has been reported that the sensitivity of the scoring systems used in the diagnosis of AA may be related to the stage of appendicitis [16]. It was reported that Alvarado score increased as inflammation increased in appendicitis [17]. In Alvarado scoring system, carried out according to the clinical and laboratory findings, a point of 4 and below is interpreted as the patient can be discharged, the patients who score between 4 and 6 should be monitored and undergo further radiological examination, and a point of 7 and above offers a significance for the diagnosis of appendicitis [2, 6]. Although a total score of 55 points and above was considered to be acceptable in terms of diagnosis of AA, it was reported that the ideal cutoff value should be accepted as 57 because of the increased risk of negative appendectomy [5, 12, 15]. Ohmann scoring system is a very simple with a high sensitivity used in the diagnosis of AA. In a study, it was reported that this scoring system was very successful in exclusion of the diagnosis of AA besides its efficacy in diagnosing AA [18]. The Ohmann scoring system was reported to be highly effective in the diagnosis of AA [19, 20].

It has been reported that differences between the sensitivity and specificity of scoring methods may be due to the degree of inflammation in the appendix and atypical clinical presentations [16]. In a study, the sensitivity was 96.2%, the specificity was 67% in patients with Alvarado score 3, and in patients with a score of 7 and above, the sensitivity was 77% and the specificity was 100%. It is reported that Alvarado scoring method can be more effective in geriatric population [21]. In another study, the sensitivity of the Alvarado scoring system was reported to be 82%, the specificity was 75% [15]. In a study of 2,359 patients in 3 different clinical trials, when the cutoff value was accepted as 57 and above, the sensitivity of Eskelinen scoring system was 72%, the specificity was 91%, the PPV was 76%, and the NPV was 89% [12]. In another study, it was found that the Ohmann scoring system correctly diagnosed 61.6% of the cases, false negativity rate was 9.3%, false positivity rate was 5%, and sensitivity ratio was 74% [8]. Yet another study reported that the sensitivity of Ohmann scoring system was 83.1% [15].

In our study, a total of 281 (50.7%) patients were diagnosed by Eskelinen, 216 (39.0%) were diagnosed by Alvarado, and 519 (93.7%) patients were diagnosed by Ohmann scoring system. In our study, the highest sensitivity was found in Ohmann scoring system; however, its specificity was found to be quite low compared with other scoring systems and the highest specificity in the study was achieved by Alvarado scoring system. A high rate of AA diagnosis was achieved with Ohmann scoring system because positive clinical and laboratory findings were detected in the patients who presented with acute abdominal pain and right lower quadrant pain. This, in turn, resulted in low specificity despite high sensitivity. According to our results, although Ohmann scoring system is a method with high sensitivity in diagnosis of AA as previously stated in 2 separate studies [8, 19], we believe that it could be more efficient modality in excluding the diagnosis. In our study, the sensitivity of Eskelinen and Alvarado scoring systems was found to be lower than the previous clinical studies. We believe that this may be due to some clinical parameters used in scoring systems. In Eskelinen, scoring system,

even if all the parameters are positive, the score is calculated to be less than 57 in case of absence of abdominal tenderness and guarding or leukocytosis alone, and the diagnosis of appendicitis becomes less likely. Similarly, in Alvarado scoring system, absence of 3 parameters such as temperature increase, floating right lower quadrant pain, nausea, vomiting and leukocytosis, or lack of any parameter along with leukocytosis results in drop of score below 7 and the diagnosis of appendicitis becomes less likely. The results obtained from our study suggest that the sensitivity in these scoring systems may vary depending on the degree of inflammation or presence of atypical clinical presentation of appendicitis.

Acute abdominal pain is characterized by variable clinical symptoms that help diagnosis in women, and several clinical pathologies such as pelvic inflammatory disease may result in clinical findings similar to AA [22]. Therefore, the sensitivity, specificity, false positivity, and negativity of clinical scoring systems in men and women can vary [10]. In addition to the scoring systems of Lindeberg [23] and Fenyö [24] where some clinical parameters are scored differently in men and women in the diagnosis of AA, there are scoring systems that consider gender as direct evaluation criteria such as The Van Way, Teicher, and Arnbjornssion [7]. In our study, the sensitivity in men and women was highest in Ohmann scoring system; however, the specificity and NPV in men were found to be 0.0%. In Eskelinen and Alvarado scoring systems, there was no significant difference between the sensitivity and specificity obtained in men and women and the same values obtained in the general patient population. In our study, the rate of negative appendectomy was also higher in women than in men (17.2% in women and 10.0% in men). The presence of more negative appendectomy rates in women can be explained by the confluence of gynecological pathologies with AA. Additionally in patients with perforated appendicitis, the specificity of Alvarado scoring system was found to be higher. In our study, Eskelinen and Alvarado scoring systems have low sensitivity rates in perforated appendicitis patients, and we think the most important reasons are that some of the parameters used in this scoring methods have high negativity rates in patients with atypical clinical presentation and perforation usually seen in patients who had poor self-care and it may be effected the evaluation of some clinical parameters used in scoring methods.

In conclusion, although more patients were diagnosed with appendicitis by Ohmann scoring system, we prefer Alvarado scoring method because it has higher specificity value compared with other two scoring methods. It is also concluded that Ohmann scoring system could be more efficient in exclusion of the appendicitis diagnosis due to its low specificity, and some clinical parameters that are scored in Eskelinen and Alvarado scoring systems may decrease the sensitivity and specificity of these methods depending on the patient population and atypical clinical presentations. Furthermore, in our study, there was a significant correlation with the pathology results and Eskelinen and Alvarado scoring systems in female patients who had a higher rate of negative laparotomy. We think that the clinical prediction rules or the 3 methods of scoring should ideally be more concordant and have higher sensitivity and PPV when the symptoms are acute or more severe. In case of less severe ambulatory patients, the clinical value of these prediction rules should be less and these patients can be referred to higher centers for 64 slice CT scan etc.

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Compliance with Ethical Standards

This study was approved by the Ethics Committee of Alanya Alaaddin Keykubat University of Medical Sciences, and all of the subjects' parents were informed regarding the details of the study, and they signed a consent form.

Conflict of Interest The authors declare that they have no conflict of interest.

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