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Analysis of Scores in Diagnosis of Acute Appendicitis in Women

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A B S T R A C T

Acute appendicitis is a common surgical condition that requires prompt diagnosis. Besides modern imaging techniques, scoring systems, based on clinical signs and symptoms and routine laboratory assessments, have been used as a diagnostic aid. However, differences in sensitivities and specificities were observed if the scores were applied to various populations and clinical settings. The purpose of this paper is to assess validity of three scores (modified Alvarado score, Ohmann score and Eskelinen score) for diagnosis of acute appendicitis in women. 126 female patients admitted for suspicion of acute appendicitis in a tertiary hospital emergency department were analyzed prospectively. Modified Alvarado score, Ohmann score and Eskelinen score were calculated at admission and compared to final diagnosis. All patients with modified Alvarado score 7 or more had acute appendicitis (100% specificity) and it can be used to determine the need for immediate appendectomy. Values of Ohmann score greater than 6 resulted in 0.9% rate of overlooked appendicitis. Besides obvious educational role, scores may help to determine the group of patients who require immediate appendectomy, therefore expediting treatment and avoid unnecessary observation or more lengthy diagnostic procedures that require highly educated and skilled senior staff. No single score may be used alone to dictate or decline surgery. Different cut-off points may also be considered for different subpopulations.

Key words: *acute appendicitis, women, diagnosis, appendectomy*

Introduction

Acute appendicitis is a common surgical condition that requires prompt diagnosis in order to minimize morbidity and avoid serious complications. Accurate identification of patients who require immediate surgery as opposed to those who will benefit from active observation is not always easy[1].

Therefore, several scoring systems have been devised to aid decision making in doubtful cases, including Ohmann[2,3], Alvarado[4], Eskelinen[5] and several others. These scores utilize routine clinical and laboratory assessments, thus being simple to use in a variety of clinical settings.

However, differences in sensitivities and specificities were observed if the scores were applied to various populations and clinical settings, usually with worse performance when applied outside the population in which they were originally created[2,3,6]. Also, geographic variation of the incidence and clinical pattern of the differentials of acute abdominal pain may impair their portability[7]. Accurate diagnosis of acute appendicitis is especially difficult in women[8], where the inaccuracy of available diagnostic methods leads to an unacceptably high negative appendectomy rate, due to gynecological disorders that frequently mimic appendicitis[8].

The purpose of this paper is to analyze and compare clinical usefulness of three scoring systems (Alvarado, Ohmann and Eskelinen) for selecting patients requiring immediate surgery from those who will benefit from additional diagnostic procedures or active observation in a population of females in an urban setting. Since these scores are designed for general population, we assessed their validity in diagnostically difficult female subpopulation which has not yet been fully investigated.

Subjects and Methods

Total of 126 female patients admitted for acute abdominal pain suspicious for acute appendicitis over a period of 12 months, were prospectively included in the study. All female patients who presented at the emer-

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TABLE 1A
MODIFIED ALVARADO SCORE

Sign/Symptom	Value
Migration of pain to the right lower quadrant	1
Anorexia	1
Nausea/Vomiting	1
Tenderness in the right iliac fossa	2
Rebound tenderness in the right iliac fossa	1
Elevated temperature (≥37,3 °C)	1
Leukocytosis (≥10^9/L)	2

TABLE 1B
THE OHMANN SCORE

Sign/Symptom	Value
Pain on compression in the lower right quadrant	4.5
Rebound pain	2.5
Absence of urinary symptoms	2.0
Continuous pain	2.0
White blood cell count ≥10000/μlL	1.5
Age under 50 years	1.5
Migration of pain to the right lower quadrant	1.0
Involuntary muscular tension (defense)	1.0

TABLE 1C
ESKELINEN SCORE

Sign/Symptom	Criterion, points	Factor
Tenderness	2=right left quadrant; 1=any other location	11.41
Rigidity	2=Yes; 1=No	6.62
Leukocyte count	2=≥10^9/L; 1=<10^9/L	5.88
Rebound tenderness	2=Yes; 1=No	4.25
Pain at presentation	2=right left quadrant; 1=any other location	3.51
Duration of pain	2=<48 h; 1=≥48 h	2.13

gency department with clinical suspicion of acute appendicitis were included in the study. Patients with other known causes of pain, as well as those with previous appendectomy were not included.

Initial patient assessment was performed in the emergency department by both surgical resident (junior physician) and the surgeon (consultant). Modified Alvarado score, Ohmann and Eskelinen scores were calculated as described[2,7,9] (Table 1A, B, C), based on the detailed data acquired from the structured, pro-forma, admission records. These data were acquired and scores calculated by the same person (resident) at the time of initial assessment. All patients with clinical suspicion of acute appendicitis were therefore included in the study and underwent surgery. The decision to operate was made by the senior surgeon (consultant), based on clinical and laboratory findings. The consultant who indicated surgery was unaware of the score. Therefore, the score had no influence on the management of the patients.

Values indicative for acute appendicitis were 5 or more for Alvarado score[9], 12 or more for Ohmann score[2] and 55 or more for Eskelinen score[7].

Intraoperative findings were recorded, and definite diagnosis was established on the basis of both intraoperative findings and histological analysis. Patients were therefore divided into three groups; those without

TABLE 2
CLINICAL AND LABORATORY FEATURES IN THREE GROUPS OF PATIENTS

	Non-inflamed appendix (N=18)			Inflamed, non-perforated appendix (N=91)			Inflamed, perforated appendix (N=17)			
	Mean	SD	p^1	Mean	SD	p^2	Mean	SD	p^3	p
Age (years)	39.44	21.27	0.390	35.40	17.64	0.000	58.41	17.78	0.003	0.000
Axillar temperature (°C)	37.21	0.65	0.443	37.07	0.66	0.189	37.32	0.62	0.657	0.355
Rectal temperature (°C)	37.82	0.76	0.997	37.82	0.58	0.009	38.29	0.58	0.048	0.030
Axillar-rectal difference (°C)	0.48	0.38	0.017	0.73	0.36	0.045	0.96	0.62	0.001	0.004
Erythrocyturia	8.35	12.27	0.338	5.13	8.07	0.000	21.00	26.60	0.004	0.000
Leukocyturia	18.44	27.45	0.151	10.81	17.66	0.035	22.35	25.68	0.573	0.059
Leukocytosis (1000/μL)	10.97	3.89	0.018	13.49	3.79	0.060	15.52	5.39	0.001	0.005
Duration of symptoms (hours)	37.83	29.90	0.852	39.30	29.23	0.013	59.53	36.58	0.037	0.038
Observation time (hours)	10.76	12.90	0.651	12.98	16.27	0.078	21.88	31.26	0.087	0.162
Alvarado score	4.83	1.54	0.028	5.74	1.60	0.141	6.35	1.46	0.005	0.017
Ohmann score	11.89	2.23	0.106	12.89	2.43	0.842	12.76	2.24	0.279	0.268
Eskelinen score	57.35	4.65	0.373	58.35	4.24	0.838	58.59	4.71	0.401	0.631

p^1 = statistical significance between patients with non-inflamed appendix and inflamed, non-perforated appendicitis; p^2 = statistical significance between patients with non-perforated acute appendicitis and patients with perforation; p^3 = statistical significance between patients with non-inflamed appendix and patients with perforation; p = statistical significance among three groups of patients.

inflamed appendix, those with inflamed but not perforated appendix, and, finally those with inflamed, perforated appendix (Table 2).

Parameters of validity (sensitivity, specificity, positive and negative predictive values and accuracy) of the three investigated scores were calculated. Comparisons between groups were performed using one-way analysis of variance with post-hoc LSD test for planned comparisons. Levels of $p<0.05$ were considered statistically significant.

Results

Overall, there were 126 female patients, with mean age 34.1 (range 15–75) years. Acute appendicitis was identified at operation and confirmed on subsequent histology in 91 (72.2%) patients, and in another 17 (18.7%) patients acute appendicitis was found with perforation and localized or generalized peritonitis. No sign of acute appendicitis was found in 18 (14.3%) patients. Among patients with non-inflammed appendix, the cause of pain was identified as the rupture of ovarian cyst (4 patients), acute adnexitis (2 patients), ischemic colitis (1 patient) and perforation of the duodenal ulcer (1 patient), whereas in others no cause of pain could have been determined (acute non-specific abdominal pain, ANSAP).

Patients with perforated appendix were significantly older compared to both those with non-inflamed appendix ($p=0.003$) as well as those with non-perforated acute appendicitis ($p<0.001$). Generally, age was in positive correlation with both the duration of symptoms ($r=0.255$, $p=0.004$) and time of first presentation ($r=0.208$, $p=0.021$) (Table 2).

All patients with modified Alvarado score 7 or more had acute appendicitis (100% specificity). On the other hand, sensitivity rate of modified Alvarado score was only 83.3% when low cut-off value of 4 or more was used (Table 3, Figure 1).

For Ohmann score, values greater than 6 resulted in only one missed acute appendicitis (0.9% rate of overlooked appendicitis). However, no clear cut-off value could be defined, and even with maximum score of 16 there was a patient with normal appendix (Table 4, Figure 2).

Although 94.4% of patients with acute appendicitis had Eskelinen score greater that 55, 6 patients with score values 45 or less represent 5.5% rate of overlooked appendicitis (Table 5, Figure 3).

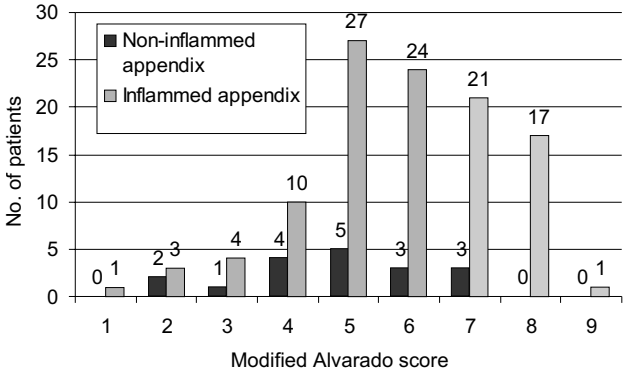

Fig. 1. Distribution of inflamed and non-inflamed appendices according to the value of modified Alvarado score.

Discussion

The diagnosis of acute appendicitis still represents one of the most difficult problems in surgery[10]. It has been for a long time a general surgical view that the removal of normal appendix is safer in questionable cases[11], and that delaying surgery for the purpose of increasing the diagnostic accuracy in patients with acute abdominal pain leads to increased rate of perforations[12]. However, such practice results in high rate of the removal of normal appendices that ranges between 15–30%[13]. On the other hand, extensive observation that results in perforated appendix may lead to a poor outcome that was avoidable.

According to previous publications, the criteria for diagnostic quality have been postulated as 15% rate of negative appendectomies, 10% rate of negative laparotomies,

TABLE 3
VALIDITY OF MODIFIED ALVARADO SCORE FOR DIAGNOSIS OF ACUTE APPENDICITIS

Cut-off value	True negative	False negative	True positive	False positive	Sensitivity	Specificity	Positive predictive value	Negative predictive value	Accuracy
≥1	0	1	107	18	99.1%	0.0%	85.6%	0.0%	85.6%
≥2	2	4	104	16	96.3%	11.1%	86.7%	33.3%	84.8%
≥3	3	8	100	15	92.6%	16.7%	87.0%	27.3%	82.4%
≥4	7	18	90	11	83.3%	38.9%	89.1%	28.0%	77.6%
≥5	12	45	63	6	58.3%	66.7%	91.3%	21.1%	60.0%
≥6	15	69	39	3	36.1%	83.3%	92.9%	17.9%	43.2%
≥7	18	90	18	0	16.7%	100.0%	100.0%	16.7%	28.8%
≥8	18	107	1	0	0.9%	100.0%	100.0%	14.4%	15.2%
≥9	18	108	0	0	0.0%	100.0%	0.0%	14.3%	14.4%

TABLE 4
VALIDITY OF OHMANN SCORE FOR DIAGNOSIS OF ACUTE APPENDICITIS

Cut-off value	True negative	False negative	True positive	False positive	Sensitivity	Specificity	Positive predictive value	Negative predictive value	Accuracy
≥4.51	0	1	107	18	99.1%	0.0%	85.6%	0.0%	85.6%
≥6.02	0	2	106	18	98.2%	0.0%	85.5%	0.0%	84.8%
≥7.01	1	4	104	17	96.3%	5.6%	86.0%	20.0%	84.0%
≥8.00	2	5	103	16	95.4%	11.1%	86.6%	28.6%	84.0%
≥8.51	2	6	102	16	94.4%	11.1%	86.4%	25.0%	83.2%
≥8.99	2	11	97	16	89.8%	11.1%	85.8%	15.4%	79.2%
≥9.50	4	11	97	14	89.8%	22.2%	87.4%	26.7%	80.8%
≥9.98	4	13	95	14	88.0%	22.2%	87.2%	23.5%	79.2%
≥10.50	4	18	90	14	83.3%	22.2%	86.5%	18.2%	75.2%
≥11.01	5	25	83	13	76.9%	27.8%	86.5%	16.7%	70.4%
≥11.49	6	31	77	12	71.3%	33.3%	86.5%	16.2%	66.4%
≥12.00	8	33	75	10	69.4%	44.4%	88.2%	19.5%	66.4%
≥12.51	13	46	62	5	57.4%	72.2%	92.5%	22.0%	60.0%
≥12.99	13	47	61	5	56.5%	72.2%	92.4%	21.7%	59.2%
≥13.50	16	70	38	2	35.2%	88.9%	95.0%	18.6%	43.2%
≥14.02	16	74	34	2	31.5%	88.9%	94.4%	17.8%	40.0%
≥14.50	17	83	25	1	23.2%	94.4%	96.2%	17.0%	33.6%
≥15.01	17	94	14	1	13.0%	94.4%	93.3%	15.3%	24.8%
>16.00	18	108	0	0	0.0%	100.0%	0.0%	14.3%	14.4%

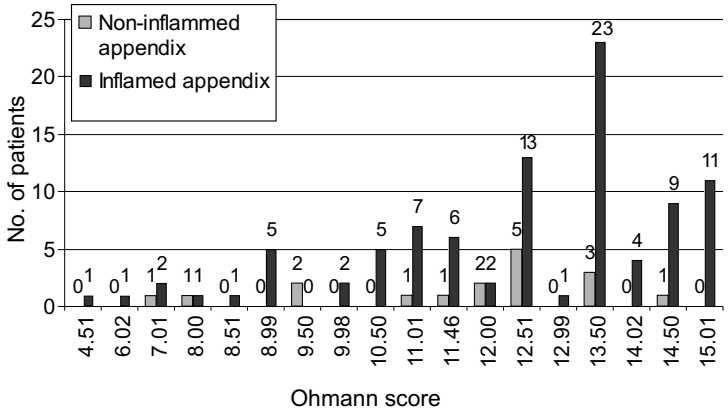

Fig. 2. Distribution of inflamed and non-inflamed appendices according to the value of Ohmann score.

TABLE 5
VALIDITY OF ESKELINEN SCORE FOR DIAGNOSIS OF ACUTE APPENDICITIS

Cut-off value	True negative	False negative	True positive	False positive	Sensitivity	Specificity	Positive predictive value	Negative predictive value	Accuracy
≥40.40	1	0	108	17	100.0%	5.6%	86.4%	100.0%	87.2%
≥42.55	1	4	104	17	96.3%	5.6%	86.0%	20.0%	84.0%
≥44.65	1	6	102	17	94.4%	5.6%	85.7%	14.3%	82.4%
≥55.35	3	17	91	15	84.3%	16.7%	85.9%	15.0%	75.2%
≥57.45	12	49	59	6	54.6%	66.7%	90.8%	19.7%	56.8%
≥59.60	15	69	39	3	36.1%	83.3%	92.9%	17.9%	43.2%
≥61.70	18	108	0	0	0.0%	100.0%	0.0%	14.3%	14.4%

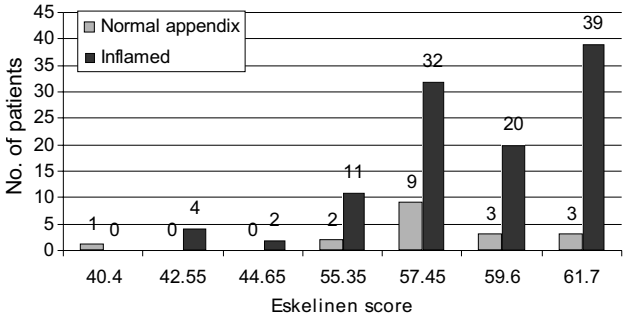

Fig. 3. Distribution of inflamed and non-inflamed appendices according to the value of Eskelinen score.

35% rate of potential perforations, 15% rate of overlooked perforations and 5% rate of overlooked acute appendicitis[3,14].

There have been many attempts to increase the accuracy of the diagnosis of acute appendicitis. Besides clinical evaluation, with the variety of clinical signs and symptoms, many of the modern diagnostic tools, such as graded compression sonography, CT and diagnostic laparoscopy have proved to be effective in the diagnosis of acute appendicitis[15–19].

Although sonography and CT increase the accuracy of the diagnosis of acute appendicitis, they are unfortunately still often unavailable around the clock in some emergency departments, especially in the absence of highly trained, experienced staff[13,20,21].

Several scoring systems that have been devised for the purpose of increasing both the sensitivity and specificity of the diagnosis of acute appendicitis had been repeatedly tested[1,2,4,5,10]. Scoring systems represent inexpensive, non-invasive and easy to use diagnostic aid[1,2].

The simplicity of the score for acute appendicitis is quite appealing. The idea of improving the diagnostic accuracy simply by assigning numeric values to defined signs and symptoms has been a goal in some of scores described[1]. Parameters comprising the score usually include general signs of abdominal illness (e.g. type, location and migration of pain, body temperature, signs of peritoneal irritation, nausea, vomiting etc) as well as routine laboratory findings (leukocytosis). Such simple scoring systems may work as expected in the original setting, but they do not take into consideration different diagnostic weights of each parameter in different subpopulation (e.g. children, women etc). Thus, scores usually did not repeat their good results when applied to different populations, which led to the creation of new scoring systems and their re-evaluation in different settings[2].

It is well known that age and gender play an important role in the clinical presentation of acute abdominal pain. As much as 50% perforation rate has been reported in children and people over 75 years of age[22]. The application of Alvarado scoring system proved to be effective in children and men, but as much as 33% negative appendectomies are reported for women[9]. Evidently, any rigid scoring system that does not respect different significances of defined signs and symptoms within different subpopulations and geographical settings will not be as effective when applied to the entire population in the emergency department.

Ohmann et al. performed a multivariate analysis, and of initial 15 parameters, 8 were included into regression model, resulting in different values being attributed to each parameter[2]. Originally, it has been proposed that patients with scores less that 6 should not be considered to have appendicitis. Patients with scores 6 or more should undergo observation, and those with scores 12 or more should proceed to immediate appendectomy[2].

In this analysis, only one patient with acute appendicitis had Ohmann score 4.5, and thereby would have been declared as normal based on original cut-off values (score less that 6) if Ohmann score alone was used to exclude the diagnosis of acute appendicitis. According to the results of this study, relying on Ohmann score alone would therefore result in only 0.9% rate of overlooked acute appendicitis, that compares favorably to generally accepted criteria of diagnostic quality[3,14]. Also, using Eskelinen score with cut-off value of 43 to refute the diagnosis of acute appendicitis would have resulted in 2 overlooked cases of appendicitis (1.8%). According to the results of this study, there is no clear cut-off value of Eskelinen score to predict patients requiring immediate surgery. All patients with modified Alvarado score 7 or greater were found to have acute appendicitis (100% specificity for cut-off value of 7), and therefore could have proceeded to immediate surgery without need for observation or lengthy diagnostic measures. This is of particular importance, since patients with perforated appendicitis had significantly longer time form the beginning of symptoms to the first presentation to the emergency department. Therefore, modified Alvarado score with cut-off values of 7 or more may be safely used to expedite appropriate surgical treatment in patients with suspected acute appendicitis.

Relatively small number of patients was included in this study. However, this study included all female patients admitted at our institution for acute appendicitis in a 12-month period, thus ensuring uniform diagnostic criteria and scoring, that may not be possible in multicentric trial or with long periods of inclusion.

Findings of this study clearly demonstrate that high score values may be used as an aid in deciding the need for immediate appendectomy, but not all scores have clear cut-off points for refuting or confirming diagnosis of acute appendicitis, as demonstrated for Eskelinen score in this study. Defining specificities and sensitivities of different scores in different subpopulations may therefore help to determine safe cut-off values for each score used.

Although large, prospective, multicentric studies are needed for the evaluation of parameters and the cre-

ation of new scoring systems, such scoring systems should prove their efficacy in all settings.

Undoubtedly, modern sonography techniques, CT and diagnostic laparoscopy are becoming main diagnostic aids to clinical diagnosis for acute abdominal pain, providing more accurate and objective diagnosis[23–25].

Scoring systems in general have a significant educational purpose, since they can help differentiate important clinical signs and symptoms, and point to different diagnostic weights of each of them in specific subpopulations according to, for example, age and gender. Also, scores may help to determine the group of female patients who require immediate appendectomy, and therefore expedite treatment and avoid unnecessary observation or more expensive diagnostic procedures that require highly educated and skilled senior staff. However, no single score may be used alone to dictate or decline surgery. Different cut-off points may also be considered for different subpopulations.

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ANALIZA BODOVANJA U DIJAGNOSTICI AKUTNE UPALE CRVULJKA U ŽENA

S A Ž E T A K

Akutna upala crvuljka je česta kirurška bolest koja zahtijeva brzu dijagnozu. Uz suvremene metode oslikavanja, bodovanje koje se osniva na kliničkim znacima i simptomima, te rutinskim laboratorijskim nalazima može se koristiti kao pomoć u dijagnostici. Međutim, primijećene su razlike u osjetljivosti i specifičnosti kod primjene bodovanja u različitim populacijama i ustanovama. Cilj ovoga rada je ocijeniti valjanost tri načina bodovanja (izmijenjeno bodovanje po Alvaradu, te bodovanje po Ohmannu i Eskelinenu) u dijagnostici akutne upale crvuljka u žena. Prospektivno je analizirano 126 pacijentica primljenih zbog sumnje na akutnu upalu crvuljka u hitnoj kirurškoj službi tercijarnog centra. Po prijemu pacijentica izračunato je izmijenjeno bodovanje po Alvaradu, te bodovanje po Ohmannu i Eskelinenu, a rezultati su uspoređeni s krajnjom dijagnozom. Sve pacijentice s vrijednostima izmijenjenog bodovanja po Alvaradu 7 ili više imale su akutnu upalu crvuljka (100% specifičnost). Vrijednosti bodovanja po Ohmannu iznad 6 rezultirale su stopom od 0,9% previđenih upala crvuljka. Osim očigledne edukacijske uloge, bodovanja mogu pomoći u određivanju grupe pacijenata kojima je potrebna hitna apendektomija, te tako ubrzati liječenje i doprinijeti izbjegavanju nepotrebnog promatranja ili dugih dijagnostičkih postupaka koji zahtijevaju visoko educirano i uvježbano starije medicinsko osoblje. Niti jedno bodovanje samo za sebe ne smije indicirati ili kontraindicirati operaciju. Za različite subpopulacije trebalo bi uzeti u obzir korištenje različitih graničnih vrijednosti.