

Validation of the Modified Alvarado Score in Patients Attending A&E Unit With Suspected Appendicitis – Prospective Clinical Study

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Abstract

Background

The aim of our prospective study was to confirm the validity, diagnostic accuracy of the modified Alvarado score developed in the Department of Surgery, University of Szeged.

Methods

138 patients were enrolled in our study between 01 January 2019 and 01 January 2020. The patient's modified Alvarado score was calculated in the Emergency Department before surgical consultation and decision of further therapy. The score was validated based on the final histology finding of the removed appendix. Additionally, potential correlation was examined between the frequency of drain usage, hospital stay, antibiotic use and the severity of the inflammation.

Results

Comparing the scores with the histological findings, specificity of the modified Alvarado score was 84.78%, its sensitivity was 97.83% (with cutoff value of 5.5). Spearman's rank correlation (0.796) and ROC analysis (area under the curve 0.968) confirmed that the modified Alvarado score has an excellent predictive value in the diagnosis of acute appendicitis. Based on the result of the Fisher's exact test, cross tabulation and Spearman's rank correlation correlation was found between the severity of the inflammation determined by the histology finding, the selected antibiotic and the duration of the antibiotic therapy, the average duration of hospitalization and drain insertion.

Conclusions

Based on the results of our study, predictive value of the new, modified score system is excellent, using this score system is safe in the differential diagnosis of acute appendicitis as an aid for non-surgical consultants in emergency care. This new score system may decrease the number of unnecessary surgical consultations, decrease waiting time of the patients and some unnecessary examinations can be avoided.

Trial Registration

Validation of the modified Alvarado score in patients presenting in the Emergency Department with right lower abdominal complaints, ethical license number: 248/2018/SZTE, date of registration: 2018.11.04., name of ethics committee: SZTE SZAKK Regionális és Intézményi Humán Orvosbiológiai Kutatásetikai Bizottság- Clinical Research Coordination Office of the University of Szeged

Background

Acute appendicitis is the most common surgical emergency. Currently, the incidence of acute appendicitis in Europe and in the United States of America is approximately 100 cases per 100,000 people per year [1]. While the incidence of appendectomy decreases, the ratio of new cases remains similar. In Hungary, the incidence of appendectomy was 100 in 1,000,000 inhabitants in a year, of which, 30 laparoscopic appendectomies were performed per 1,000,000 inhabitants [2]. Mortality of the disease was 0.7%, in conclusion, it is responsible for 100 deaths in a year in Hungary [3].

During the last few years, there was a paradigm shift in the diagnosis and treatment of the disease: nowadays the main question is not whether to perform laparoscopy or open surgery but whether to perform surgery or not in early complication free cases. There are several questions in the diagnosis as well regarding the selection of imaging studies, the efficacy of score systems. Nothing shows the importance of discussion about the common, well-known disease more than the fact that there were two large consensus conferences during the last 6 years about the current issues of acute appendicitis: the first consensus conference was organized by the World Society of Emergency Surgery (WSES) and was held in Jerusalem in 2015 [4], the following consensus conference was held in 2020 discussing the current issues as well [5].

Various score systems were developed during the last few years to enhance the diagnosis. Overall, score systems help in the clinical decision making, may decrease the number of unnecessary surgical consultations, hospital admissions, and the ratio of negative appendectomies. The greatest advantage of the score systems is that they help identifying low risk patients, therefore unnecessary imaging studies and negative surgical explorations may be avoided.

The best known score system is the Alvarado score, which was created by Alvarado in 1986 with the retrospective analysis of patients having appendectomy. The score system contains nine diagnostic criteria and the further care of the patient depends on the determined score [6]. The Paediatric Appendicitis Score, the Appendicitis Inflammatory Response Score (AIR), the Raja Isteri Pengiran Anak Saleha Appendicitis Score (RIPASA), and the Adult Appendicitis Score (AAS) are notable as well. Kularatna et al. summarized the results regarding the validation of the greatest score systems, based on their results, diagnostic accuracy was the highest in case of AIR, sensitivity was 92%, specificity was 63% [7].

Between 01.09.2011 and 31.12.2012, we conducted a prospective randomized trial in the Emergency Department of the University of Szeged comparing the diagnostic accuracy of the best known score system for appendicitis, the Alvarado score with the standard clinical judgment of the surgeon. In Group A the diagnostic decision was based on the Alvarado score and in Group B it was based on the clinical judgement of the surgeon. The final histology was compared with the decision of each group and specificity and sensitivity was calculated. (Impact of the Alvarado score on the diagnosis of acute appendicitis: comparing clinical judgment, Alvarado score, and a new modified score in suspected appendicitis: a prospective, randomized clinical trial) [8]. Specificity of the Alvarado score (group A) was 88.9%; that of the standard clinical judgment (group B) was 94.8% ($p=0.320$). In group A, the ratio of negative appendectomies was 8.42%, this ratio was 3.62% in group B ($p=0.160$). In conclusion, the diagnostic accuracy of the Alvarado score is good, but is inferior to the standard clinical judgment of the surgeon. However, it can be used as an excellent diagnostic aid in the Emergency Department in determining the further therapeutic algorithm (surgical consultation, additional imaging studies, discharge, etc.). Arzu et al. compared the diagnostic accuracy of the emergency medicine residents using the Alvarado score with that of surgical residents not using the score in a prospective trial. They found that the sensitivity of the Alvarado score was 95.4 %, specificity was 45.7%. No significant difference was found between emergency medicine residents using the score and surgical residents not using the score regarding positive and negative predictive values [9]. In another prospective study, You et al. compared the predictive value of the judgment of surgical residents, emergency medicine residents, the predictive value of the Alvarado score and that of the abdominal CT. In this study, the diagnostic accuracy of abdominal CT was the highest, followed by the Alvarado score. The resident-predicted probabilities had the lowest predictive value, but no difference was found between the diagnostic accuracy of surgical vs. non-surgical residents [10].

Regarding the fact that the diagnostic accuracy of the Alvarado score was inferior to the accuracy of the standard clinical judgment, we tried to develop a new, more sensitive, modified score system by weighing each parameters (using linear regression). We selected parameters not involved in the score before, but were considered to be important based on our clinical experience, and were found to be statistically significant in the diagnosis of acute appendicitis (ultrasound examination), and the less significant elements were not used in our score (such as: difference between rectal and axillary temperatures). The diagnostic accuracy of the developed modified Alvarado score increased further (Table 1) [8].

Table 1: Modified Alvarado score

	Score value
Nausea, vomiting	2
Right lower abdominal tenderness	2
Indirect sign positivity (1-2)	1
Indirect sign positivity (≥ 2)	2
Leukocytosis >10 g/l	1
Leukocytosis >15 g/l	2
Ultrasound examination	2

1-4 scores: discharge, 5-6 scores: admission, observation,
> 7 scores: emergency surgery.

In this prospective study, our aim was to validate the score system and confirm that the modified Alvarado score is a reliable aid for non-surgical residents in the differential diagnosis of acute appendicitis in patients presenting with right lower abdominal pain with methods other than statistical methods. After validation, the modified Alvarado score may be used in a protocol in the daily practice of the Emergency Department in patients presenting with right lower abdominal complains. This score system may help avoiding unnecessary

surgical consultations, therefore waiting time of the patients may decrease. On the other hand, time till the admission to a surgical department may be shorter in patients with high scores, making time till the surgery shorter.

Methods

Our study was conducted between 01.01.2019 and 01.01.2020 in the Emergency Department of the University of Szeged. Our aim was to validate the modified score system in case of patients who presented at the Emergency Department (ED) of the University of Szeged with right lower abdominal complaints suspected to have acute appendicitis and who were at least 18 years old. The title of our prospective study: Validation of the modified Alvarado score in patients presenting in the Emergency Department with right lower abdominal complaints, ethical license number: 248/2018/SZTE.

After signing the participation consent form the modified Alvarado score was calculated and recorded in case of patients presenting in the ED by the first emergency medicine resident examining the patient before the surgical consultation. The surgical consultant did not know this score, and determined the patient's therapy irrespective of the score. The score was validated by comparing the final histology report in case a surgery was performed with the original score (whether the surgery was indicated, and whether indication was present based on the score or not), whether readmission was required after being discharged due to the worsening of the complaints after the surgery.

In addition, we evaluated whether there was a relationship between the Alvarado score and the severity of the inflammation. We measured the diagnostic accuracy (specificity, sensitivity) of the ultrasound examination as well, and we analyzed the correlation between the severity of the inflammation and the duration of antibiotic therapy, drain usage or number of days spent in the hospital.

In our clinical practice, based on the international recommendations, patients received one-shot antibiotic prophylactic therapy: 1.5 g cefuroxime and 500 mg metronidazole. In our study, from the 60 patients who had surgery, 37 patients received one dose Zinacef (cefuroxime), Klion (metronidazole) antibiotic prophylaxis (n=37), 3 patients received Ciprobay (ciprofloxacin), Klion (metronidazole) prophylaxis due to penicillin allergy (n=3). Naturally, prophylactic therapy may be or have to be continued based on the intraoperative image, the severity of the inflammation, antibiotic therapy may be switched based on for example the intraoperative bacteriological sampling. In our study, in 3 cases, additional IV Rocephin (ceftriaxone) - Klion (metronidazole), in 1 case Tienam (imipenem/cilastin) - Klion (metronidazole) antibiotic therapy was continued, and 15 patients received oral antibiotic after the initial intravenous antibiotic therapy (Zinnat [cefuroxime] + Klion [metronidazole] n=13, Cifran [ciprofloxacin] - Klion [metronidazole] n=1).

Drain was inserted in accordance with the intraoperative status in all cases (perforated appendicitis, peritonitis) based on individual evaluation. Patients were classified into 2 groups based on the insertion of a drain: 0 - no drain was used as no surgery was performed or surgery was performed but drain was not used (n=115), group 1 - drain was inserted (n=23).

In our Department, the duration of hospitalization is determined individually in all cases, patients spend 24-48 hours in our Institute in case of complication free appendicitis, this may change in case of severe inflammation or if antibiotic therapy is required. In our study, 13 patients spent 24 hours in the hospital, 23 patients spent 48 hours in our Department, 9 patients were hospitalized for 3 days, 2 patients were hospitalized for 4 days, 4 patients were hospitalized for 5 days. 5 patients were hospitalized for an even longer period of time: the days of hospitalization was 6 in 4 cases and 9 in one case.

Statistical methods

Continuous data were expressed as mean±SD, categorical data were expressed as frequency and relative frequency in cross tabulations. Relationship between categorical variables was tested with Chi-square test for independence or Fisher's exact test. Monotonous relationship between continuous (or ordinary) variables (such as scores) was examined with Spearman's rank correlation coefficient. Predictive performance of the modified Alvarado score was investigated with ROC (receiver operating curve) analysis. AUC (area under ROC curve), 95% confidence interval for AUC and significance of the AUC were calculated. 95% Clopper-Pearson confidence intervals were constructed for sensitivity and specificity values. Statistical analysis was carried out with IBM SPSS26 statistical software. A p-value p<0.05 was regarded as statistically significant.

Results

138 patients were enrolled in our study between 01.01.2019 and 01.01.2020. Average age of the patients was 32 years (18-67 years). There were 93 female and 45 male participants. The average value of the modified Alvarado score was 6.5: 1-n=3, 2-n=17, 3-n=13, 4-

n=27, 5-n=16, 6-n=12, 7-n=27, 8-n=19, 9-n=3, 10-n=1. Main groups were the following: 1-4 scores (discharge) n=60, 5-6 scores (observation) n=28, 7-10 scores (emergency surgery) n=50.

The value of the modified Alvarado score in the diagnosis of acute appendicitis: the modified Alvarado scores of the patients were compared with the final histology findings (0 – acute appendicitis was not confirmed, as no surgery was performed or the histology was negative (n=87), group 1 – another disease was confirmed (tumor, diverticulum) (n= 5), group 2 – slight inflammation (simple acute appendicitis, phlegmonous acute appendicitis, superficial acute appendicitis) (n=20), group 3 – severe inflammation (ulcero-phlegmonous acute appendicitis, gangrenous acute appendicitis, perforation) (n=26). Comparing the scores with the histological findings, specificity of the modified Alvarado score was 84.78% (95% Clopper-Pearson confidence interval: 75.79% to 91.42%), sensitivity was 97.83% (95% confidence interval: 88.47% to 99.95%).

As a result, a strong, significant Spearman’s rank correlation was found between the modified Alvarado score and the final histology finding: 0.796 (p<0.001). The above figure shows that no negative pathological findings were present above a score of 4, that is the value of the pathological result was 0 (Figure 1).

The pathological finding was coded as 0 if the score was 0 or 1 (no appendicitis present) and 1 if the score was 2 or 3 (appendicitis was present), ROC analysis showed an area under the curve value of 0.968 (95% C-I: 0.939, 0.997, p<0.001), which suggests good separability (Figure 2).

In our study, we tried to determine whether the cut-off values used in case of the original Alvarado score are applicable in case of the modified Alvarado score as well: the previous two cut-off values were: score of 4 (acute appendicitis is not likely to be present below this value) and score of 7 (surgery is recommended above this value regarding the fact that the likelihood of appendicitis is high), and there was a “gray zone” of scores 5-6 in case of which further observation or additional imaging studies (CT) were required. We found that the risk of appendicitis is low in case of a score of 4 using the modified Alvarado score as well, and the risk is high above a score of 7. A score of 5-6 indicates closer observation and repeated score calculation, in some cases, additional imaging studies may be required (acute CT examination) (Table 2 and Figure 3).

Table 2: Cross tabulation of the modified Alvarado score and the histology numerical code

	Pathology numerical code					Total
	0	1	2	3		
Modified Alvarado score	0	3	0	0	0	3
	1	3	0	0	0	3
	2	17	0	0	0	17
	3	13	0	0	0	13
	4	25	1	1	0	27
	5	16	0	0	0	16
	6	8	1	2	0	11
	7	2	2	8	14	26
	8	0	1	7	10	18
	9	0	0	2	1	3
	10	0	0	0	1	1
Total		87	5	20	26	138

Horizontal line presents the possible cutoff values, blue line refers to sensitivity (in function of the possible cutoff values) and red line presents specificity.

The patient was discharged based on the clinical status in 78 cases, the Alvarado score was below 4 in all of these cases. Repeated consultation was performed 24 hours later in one case, and the surgeon decided to perform surgery (repeated Alvarado score was 7). Surgery was performed in 60 patients: laparoscopic appendectomy was performed in 56 cases, adhesiolysis was performed in 1 case, right hemicolectomy was performed in 1 case, Hartmann's procedure was performed due to sigmoid diverticulitis in 1 case, and only explorative surgery was performed in 1 case. From the 56 laparoscopic appendectomies, drain was left in the patient in 23 cases. No conversion was required. Hemolock clips were used for the closure of appendicular stumps in 55 cases, Endo GIA was required in one case due to the severity of the inflammation.

In our study, 60 patients had surgery, 37 of these patients received Zinacef (cefuroxime), Klion (metronidazole) antibiotic prophylaxis once (n=37), 3 patients received (ciprofloxacin), Klion (metronidazole) prophylaxis due to penicillin allergy (n=3). Naturally, prophylactic therapy may be or have to be continued based on the intraoperative image, the severity of the inflammation, antibiotic therapy may be switched based on for example the intraoperative bacteriological sampling. In our study, in 3 cases, additional IV Rocephin (ceftriaxone) - Klion (metronidazole), in 1 case Tienam (imipenem/cilastin) - Klion (metronidazole) antibiotic therapy was continued, and 15 patients received oral antibiotic after the initial intravenous antibiotic therapy (Zinnat [cefuroxime] + Klion [metronidazole] n=13, Cifran [ciprofloxacin] - Klion [metronidazole] n=1).

In addition, we evaluated the correlation between the severity of the inflammation (based on the final histology report) and the type and duration of the antibiotic therapy. Based on the severity of the inflammation (pathological finding), we classified the patients into four groups: 0 – acute appendicitis was not confirmed, as no surgery was performed or the histology was negative (n=87), group 1 – another disease was confirmed (tumor, diverticulum) (n= 5), group 2 – slight inflammation (simple acute appendicitis, phlegmonous acute appendicitis, superficial acute appendicitis) (n=20), group 3 – severe inflammation (ulcero-phlegmonous acute appendicitis, gangrenous acute appendicitis, perforation) (n=26). Based on antibiotic therapy, 3 groups were created: 0 - no antibiotic therapy was administered (n= 80), group 1 - one shot IV antibiotic prophylaxis (n=40), group 2 - antibiotic therapy (n=18).

Significant correlation was found between the severity of the pathology and the duration of the antibiotic therapy. Spearman's rank correlation confirmed this correlation to be significant, but moderate ($r=0.605$, $p<0.001$). The statistical correlation confirms the correctness of the clinical judgment, which means that therapeutic (longer) antibiotic therapy is administered if it is indicated.

Patients were classified into 2 groups based on the insertion of a drain: 0 - no drain was used as no surgery was performed or surgery was performed but drain was not used (n=115), group 1 – drain was inserted (n=23).

Based on the pathology, the patients were classified into 4 groups as mentioned above: 0 – acute appendicitis was not confirmed, as no surgery was performed or the histology was negative (n=87), group 1 – another disease was confirmed (tumor, diverticulum) (n= 5), group 2 – slight inflammation (simple acute appendicitis, phlegmonous acute appendicitis, superficial acute appendicitis) (n=20), group 3 – severe inflammation (ulcero-phlegmonous acute appendicitis, gangrenous acute appendicitis, perforation) (n=26).

Relationship was found between drain insertion and the severity of inflammation, Fisher's exact test found this relationship to be significant ($p<0.001$), which means that drain is not inserted routinely into the abdominal cavity in case of appendectomies, the decision was made by the operating surgeon depending on the intraoperative finding. The clinical decision is confirmed by the result of the statistical analysis regarding the histology finding (Table 3).

Table 3: Relationship between pathological severity and drain insertion (cross tabulation)

			Drain		Total
			0	1	
Pathológia számkód	0	Count	81	6	87
		% within Pathology number code	93,1%	6,9%	100,0%
	1	Count	3	2	5
		% within Pathology number code	60,0%	40,0%	100,0%
	2	Count	14	6	20
		% within Pathology number code	70,0%	30,0%	100,0%
	3	Count	17	9	26
		% within Pathology number code	65,4%	34,6%	100,0%
Total		Count	115	23	138
		% within Pathology number code	83,3%	16,7%	100,0%

We analyzed the correlation between the duration of hospitalization (days) and the severity of the inflammation (based on the pathological finding: 0 – acute appendicitis was not confirmed, as no surgery was performed or the histology was negative (n=87), group 1 – another disease was confirmed (tumor, diverticulum) (n= 5), group 2 – slight inflammation (simple acute appendicitis, phlegmonous acute appendicitis, superficial acute appendicitis) (n=20), group 3 – severe inflammation (ulcero-phlegmonous acute appendicitis, gangrenous acute appendicitis, perforation) (n=26), that is whether there is correlation between the severity of the inflammation and the duration of hospitalization. In our study, 13 patients spent 24 hours in the hospital, 23 patients spent 48 hours in our Department, 9 patients were hospitalized for 3 days, 2 patients were hospitalized for 4 days, 4 patients were hospitalized for 5 days. 5 patients were hospitalized for an even longer period of time: the days of hospitalization was 6 in 4 cases and 9 in one case.

The average duration of hospitalization was 2,625 days (1-9 days).

Spearman's rank correlation found positive and significant relationship between the hospitalization time and severity, meaning that hospitalization is longer in case the inflammation is likely to be more severe. Rank correlation was 0.71 ($p < 0.001$), moderately strong.

Ultrasound examination was performed in all cases, regarding the fact that the ultrasound examination is part of the modified Alvarado score: in 88 cases, the ultrasound did not confirm acute appendicitis, appendicitis was confirmed in 50 cases based on the ultrasound image. Additional CT examination was performed in 11 cases, when the ultrasound was negative. From these examinations, CT confirmed appendicitis in 7 cases, 3 patients had negative CT findings, 1 patient had intestinal conglomerate in the right lower abdomen with abscess formation.

The diagnostic accuracy of the imaging methods was calculated by comparing the results of the ultrasound examination with the final histology findings: sensitivity was 82.6%, specificity was 87%. In can be concluded, that the predictive value of this imaging method is good (Table 4).

Table 4: Cross tabulation of ultrasound (US) finding and histology finding

			Histology finding		Total
			0	1	
US finding	0	Count	80	8	88
		% within Histology	87.0%	17.4%	
	1	Count	12	38	50
		% within Histology	13.0%	82.6%	
Total		Count	92	46	138

Specificity and sensitivity of the ultrasound were highlighted as bold italic fonts.

Discussion

Our previous prospective study (Impact of the Alvarado score on the diagnosis of acute appendicitis: comparing clinical judgment, Alvarado score, and a new modified score in suspected appendicitis: a prospective, randomized clinical trial) confirmed that the Alvarado score can be used in the diagnosis and can help emergency medicine physicians in the differential diagnosis of the disease. The WSES 2020 guideline states that in case of scores below the cut-off value of the Alvarado score (5 scores), acute appendicitis can be excluded with adequate sensitivity, although the Alvarado score's true value is that it may help reducing the waiting time in the emergency department, and avoid unnecessary radiological examinations, surgical consultations [11].

Analyzing all results with statistical methods, we concluded that our modified Alvarado score involving the ultrasound examinations' finding, excluding certain parameters, while emphasizing others may increase the diagnostic accuracy. The aim of our present study was to validate the modified score in the practice.

138 patients having right lower abdominal complaints participated in our prospective clinical study, we confirmed that performing an ultrasound examination in all cases has high sensitivity (82.6%) and specificity (87%). In accordance with its good predictive value, it should be part of the criteria of the Alvarado score, as it provides further help in specifying the diagnosis of the disease. These results are in line with international data stating that the specificity of the ultrasound examination is 95% and its sensitivity is 76% [12].

In our study, the average modified Alvarado score was 6.5. 79 patients were discharged based on clinical judgment, the Alvarado score correlated with this decision, it was below 4 all these cases. In one case (1.3%), readmission was required and appendectomy was performed, but the recalculated Alvarado score was increased (7 scores) compared with the previous value, 4 scores.

An important question is whether the cut-off values of the original Alvarado score: 5 scores (below this value, the risk of appendicitis is low) and 7 scores (above this value, the risk of appendicitis is high, surgery is recommended) are applicable in case of the modified Alvarado score and what the treatment strategies should be in the grey zone (5 to 6 scores) (observation, further imaging studies). A study performed in 2011 evaluated these cut-off values in case of the original Alvarado score. The cut-off value of 5 had a sensitivity of 99% in excluding appendicitis. A value of 7 to 10 scores had 82% specificity in diagnosing appendicitis [13].

Another study analyzed the involvement of the results of the CT examination in the original score system regarding the fact that a score between 5 to 6 proved to have only 35.6% sensitivity in diagnosing the disease, while the sensitivity of the CT examination in this population was 90.4% [14]. Therefore there is no need to perform a CT examination in case of a score of 0-3, as the risk of appendicitis is very low, in case of a score of 7-10, surgical consultation is required. CT examination is indicated in case of a score of 4 to 6, but rather in case of a score of 5 to 6. Naturally, radiation exposure of the CT examination should be taken into account as well as its significant cost and the fact that it may significantly increase the time till the surgery.

However, the ultrasound examination should definitely be part of the score system as an independent criterion, as it has no radiation exposure, it is easily accessible, cheap, can be repeated for several times, and has an excellent predictive value in case of an experienced radiologist.

A total of 60 patients had surgery: laparoscopic appendectomy was performed in 56 cases and other surgical intervention was performed in 4 cases based on the intraoperative image. Drain was inserted in 23 cases (41%). In accordance with the latest literature

data, leaving a draining in the surgical site does not have any benefits even in case of complicated appendicitis. Cochrane et al. analyzed 6 randomized controlled studies in 2019, and found that the ratio of post-operative abscesses or wound infections did not decrease with drain insertion, although drain insertion increased the duration of hospitalization with 2.17 days [15]. Our results confirmed that the surgeon was more likely to insert a drain in the surgical site in case of a more severe inflammation. Cross tabulation and Fisher's exact test confirmed that drain insertion correlates with the severity of the inflammation. Fisher's exact test revealed that this correlation was significant. However, prolonged hospitalization and prolonged recovery mentioned in the literature [16, 17] were not the consequences of drain insertion, but the severity of inflammation in our experience. The drain was removed on the second postoperative day if no abnormal discharge emptied via the drain.

The average duration of hospitalization was 2,625 days. Correlation was found between the severity of the inflammation and the number of days spent in the hospital. Spearman's rank correlation found positive and significant rank correlation between these two factors (0.71, moderately strong). Ziang et al. published a retrospective analysis in 2020 regarding factors influencing the duration of hospitalization. Similarly, significant correlation was found between the duration of hospitalization in days and the severity of inflammation: hospitalization was longer than 3 days in case of 45.8% of patients having complicated appendicitis compared with patients having an uncomplicated appendicitis, where hospitalization lasted for more than 3 days only in 9.5% ($p < 0,01$) [18].

A significant but not strong correlation was found between the duration of the antibiotic therapy and the severity of inflammation with histology based on our statistical analysis. Histological examination of the 56 appendices found severe inflammation in 26 cases. "Longer" antibiotic therapy had to be administered in 19 cases, while one shot antibiotic prophylaxis was administered in 37 cases. Based on the latest recommendations, one shot prophylaxis is enough in case of non-complicated appendicitis to prevent wound infection and the development of intra-abdominal abscesses [19, 20]. The optimal time for the administration of prophylactic antibiotic therapy is within one hour before the incision [21]. Based on data from large international cohort studies, post-operative antibiotic therapy is required in the treatment of complicated appendicitis to prevent the development of intra-abdominal abscesses, but therapy should not be longer than 3-5 days [22-23-24].

Clinical score systems alone help to differentiate the so-called low-risk patients who are not likely to have acute appendicitis. Andersson et al. found in their study that using the AIR (Appendicitis Inflammatory Response) score resulted in significantly less imaging study requests, fewer unnecessary surgical admissions, and fewer negative explorative surgeries [25]. The Adult Appendicitis Score (AAS) showed similar results, this score divides the patients into three groups: low, moderate and high risk. ROC analysis showed that the diagnostic accuracy was significantly higher compared with the Alvarado score or the AIR score [26].

Relatively strong Spearman's rank correlation (0.796) was found between the Alvarado score modified by us and the final histological result. ROC analysis showed an area under the curve of 0.968, which shows good separability. Our prospective clinical study confirmed that the modified Alvarado score has an excellent predictive value in the diagnosis of acute appendicitis, its great advantage is that it involves the first choice imaging diagnostic study, the results of the ultrasound examination.

Conclusions

The predictive value of the new, modified score developed in the Department of Surgery, University of Szeged is excellent, and it can be used safely in case of right lower abdominal complaints in the diagnosis and differential diagnosis of acute appendicitis. It is important that unlike other score systems, it involves an imaging study, the ultrasound examination, which is a fast and easily accessible method, and which has a good predictive value in the diagnosis of acute appendicitis in accordance with international literature. It serves as an aid for non-surgical physicians. Using this score system in the everyday practice in the Emergency Departments may rationalize patient care pathways, decrease the number of unnecessary surgical consultations and reduce waiting time for patients.

Abbreviations

AAS- Adult Appendicitis Score

AIR- Appendicitis Inflammatory Score

AUC- Area Under the Curve

A&E Unit- Acute and Emergency Unit

CT- Computertomography

ED- Emergency Department

RIPASA- Raja Isteri Pengiran Anak Saleha Appendicitis Score

ROC- Receiver Operating Curve

SD- Standard Deviation

US- Ultrasound

WSES- World Society of Emergency Surgery

Declarations

Ethics approval and consent to participate:

Trial Registration: Validation of the modified Alvarado score in patients presenting in the Emergency Department with right lower abdominal complaints, ethical license number: 248/2018/SZTE, date of registration: 2018.11.04., name of ethics committee: SZTE SZAKK Regionális és Intézményi Humán Orvosbiológiai Kutatásetikai Bizottság- Clinical Research Coordination Office of the University of Szeged

Consent for publication: Not applicable.

Availability of data and materials: The datasets used and analysed during the current study are available from the corresponding author on reasonable request.

Competing interest: The authors declare that they have no competing interest.

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Author's contributions: ME collected, analyzed and interpreted the data of the patients and was a major contributor in writing the manuscript, SZA collected the data of the patients, SZs was a contributor in writing the manuscript, RF helped in the statistical analysis, PZ helped in the planning and organization of the study, LGY was a major contributor in writing the manuscript. All authors read and approved the final manuscript.

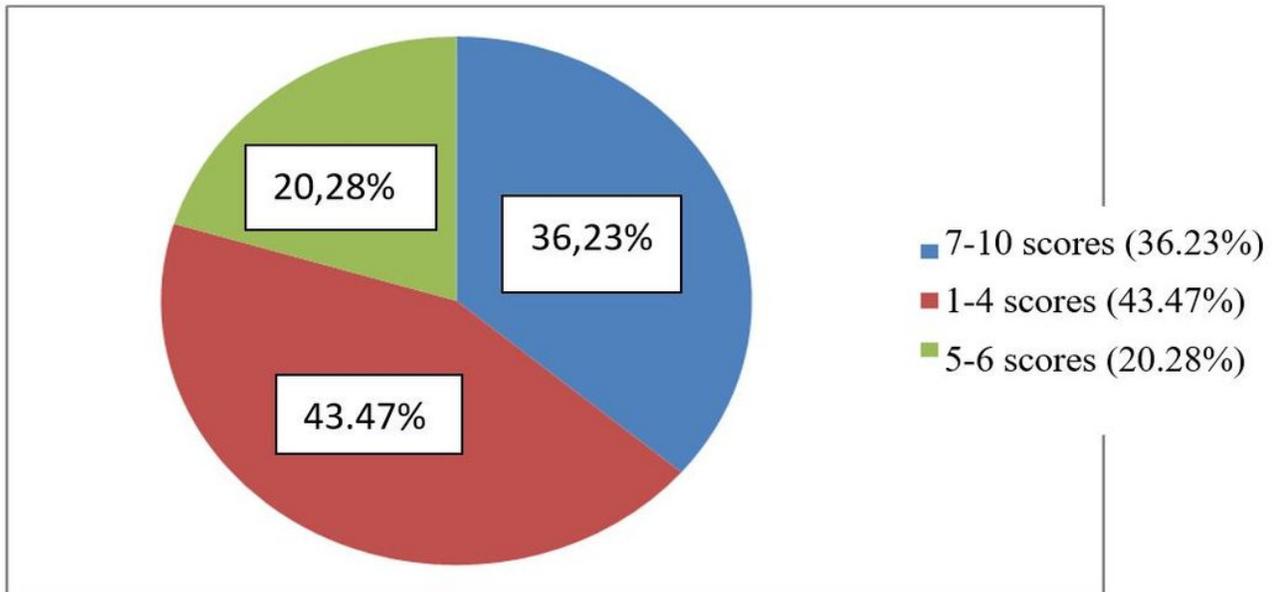
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Figures



1-4 points- emission, 5-6 points-observation, 7-10 points- surgery (n=138)

Figure 1

Alvarado score values

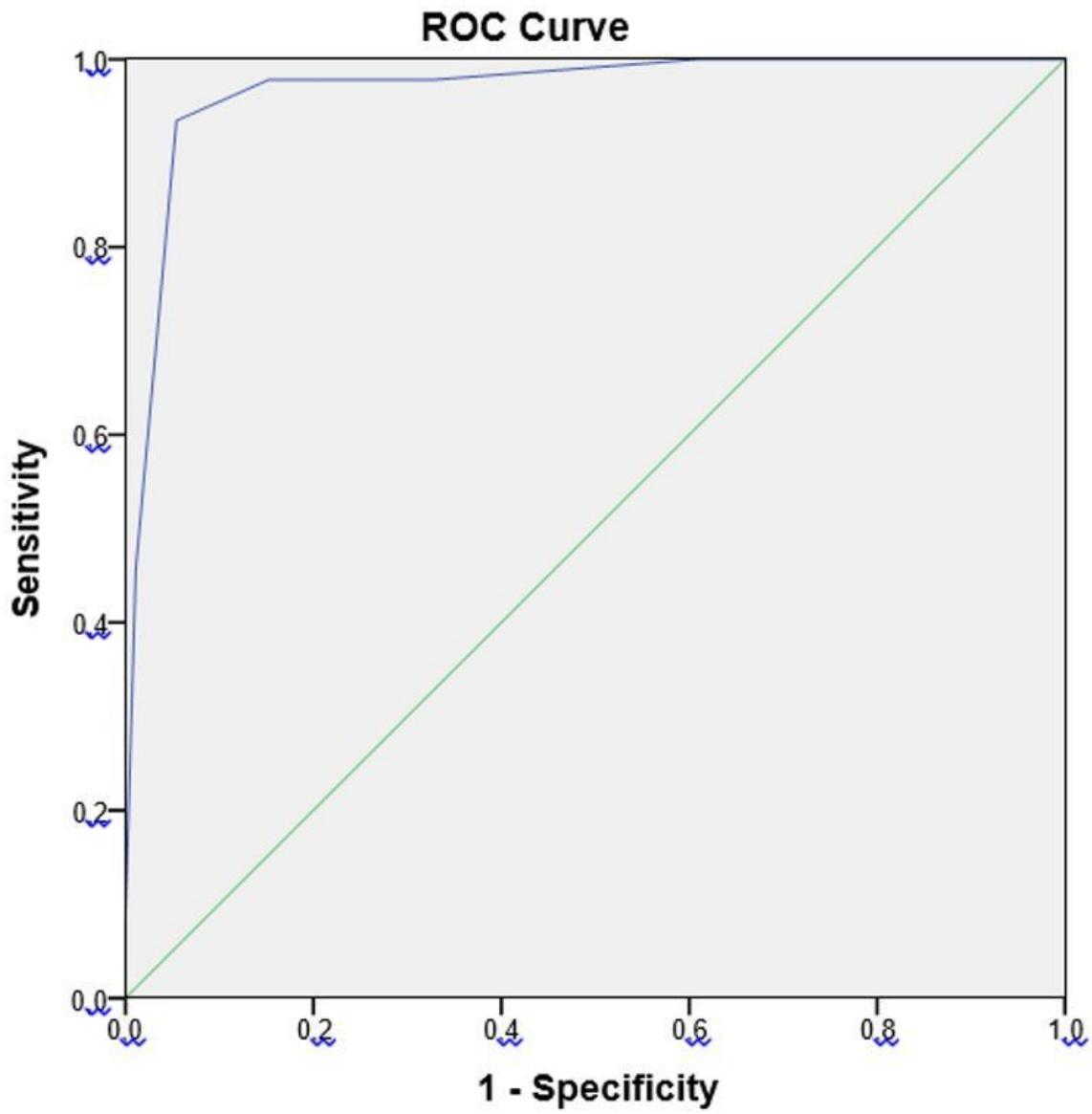


Figure 2

ROC curve of the modified Alvarado score and the severity of the inflammation.

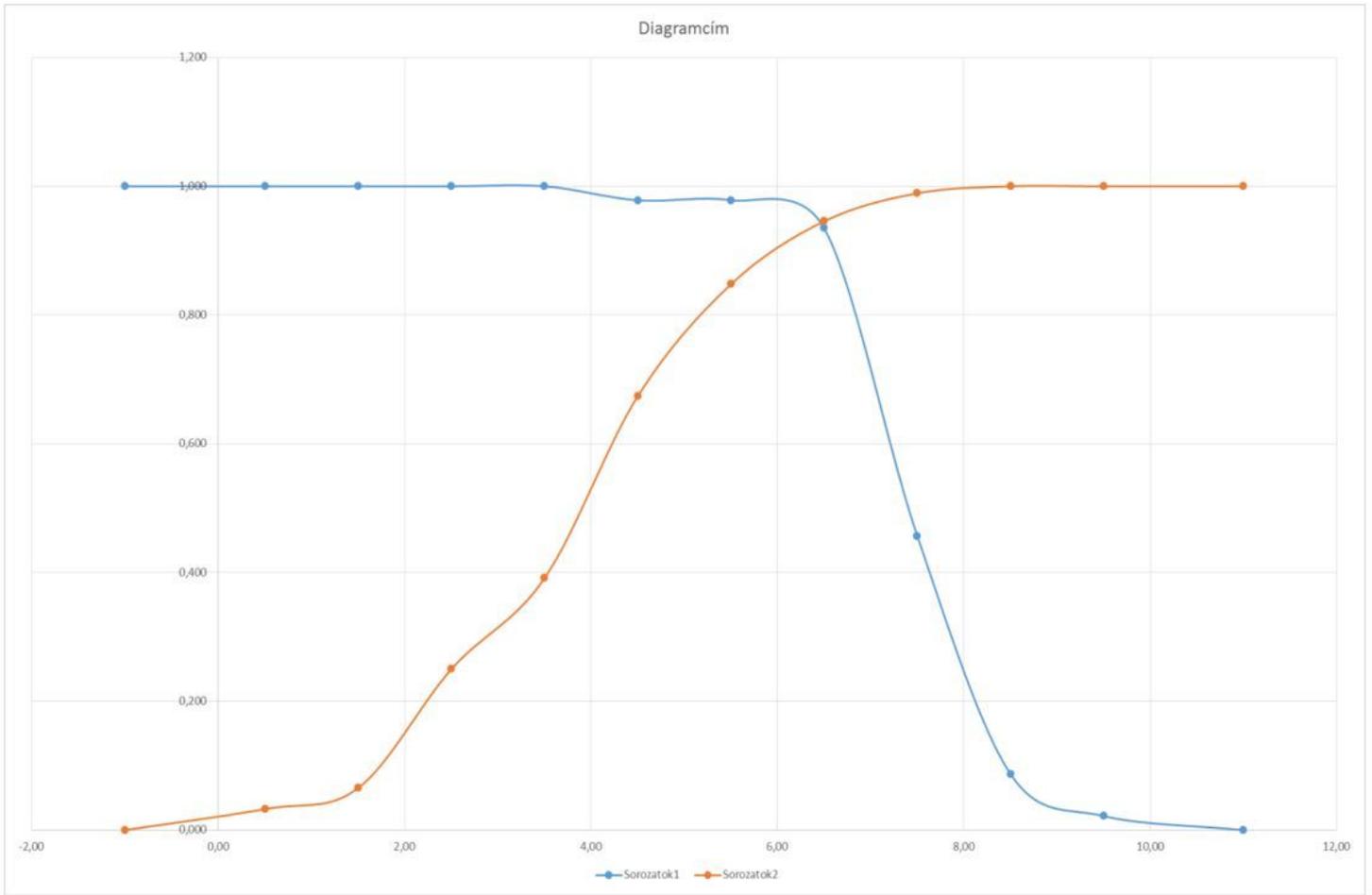


Figure 3

Relationship between the modified Alvarado score and the histology result.