The accuracy rate of Alvarado score, ultrasonography, and computerized tomography scan in the diagnosis of acute appendicitis in our center

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Abstract

Objective: In this study, we aim to compare the relationship between the Alvarado score, ultrasonography, and multislice computerized tomography (CT) findings used for the diagnosis of the patients who presented to our emergency unit with clinical features suggestive of acute appendicitis.

Materials and Methods: Seventy-four patients operated with the diagnosis of acute appendicitis were included in the study. The demographic characteristics of the patients, physical findings, blood parameters, Alvarado scores, the radiological method used for the diagnosis, the surgical methods (open or laparoscopic) and the pathology results were recorded on the standard proforma. The collected data were analyzed with Statistical Package for Social Sciences (SPSS 15 for Windows, SPSS Inc., Chicago, Illinois, USA) computer program.

Results: During study period, the sensitivity of ultrasonography was found to be as 71.2%, specificity as 46.7%, the positive predictive value (PPV) as 82.2%, the negative predictive value (NPV) as 31.8%, and the accuracy rate was determined as 65.7%. The sensitivity of tomography was determined as 97.2%, the specificity as 62.5%, PPV as 92.1%, and NPV as 83.3%, and the accuracy rate was determined as 90%. The sensitivity of the Alvarado score was calculated as 54%, the specificity as 73.3%, the PPV as 88.2% and the NPV as 29.7%, and the accuracy rate was determined as 57.7%.

Conclusion: In conclusion, computerized tomography (CT) was found to have higher specificity and sensitivity than Alvarado score and USG which are not sufficient on their own for taking the decision for surgery. We also found that CT scan had lower negative laparotomy rate when compared with the other two modalities.

Key words: Alvarado score, appendicitis, computerized tomography, ultrasonography

Introduction

Acute appendicitis is the most common cause of abdominal pain, which requires emergency surgery.[1] In acute appendicitis, most of the patients present with a typical clinical picture, and the diagnosis can be made by relying on the clinical and laboratory findings. However, 20-33% of the patients have atypical clinical and laboratory findings. In this situation, it is becoming difficult to take diagnosis, hence radiologic methods are needed.[2] Early diagnosis in the acute appendicitis decreases the complications of appendicitis like perforation and peritonitis. Before the invention of computerized tomography (CT) and ultrasonography (USG), various clinical scoring systems based on the medical history, physical examination, and laboratory findings were being used in the diagnosis of appendicitis. The Alvarado score is a well-tested and widely published 10-point clinical scoring system. An Alvarado score of 7 or more was recommended for any appendectomy diagnosis.[3] Recently, study has shown

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that CT scan is superior to USG to show appendix and inflammation surrounding appendix directly.[4]

In this study we aimed to search the relation between Alvarado score, USG, and CT findings of patients taking the diagnosis of acute appendicitis.

Materials and Methods

This study was carried out having obtained approval from the ethics committee (Erciyes University School of Medicine Ethics Committee (2012/339), Kayseri, Turkey) and the files of the patients who had presented to the Emergency Medicine Department between January 2010 and February 2012, and who had been operated with the preliminary diagnosis of acute appendicitis were evaluated retrospectively.

Inclusion criteria for the study:
- Patients taking the acute appendicitis in the emergency department
- Patients operated with the initial diagnosis of acute appendicitis
- Patients older than 18-year-old.

The demographic characteristics of the patients, physical examination findings, concomitant diseases, blood parameters, the radiological method used for the diagnosis, the surgical findings, and the pathology results were recorded on the study form for data collection.

The Alvarado score was calculated as described in the literature.[5] The Alvarado score is a 10-point scoring system for the diagnosis of appendicitis, based on the signs and symptoms, and the blood neutrophil count [Table 1]. The patients were assigned to three groups based on the score:
- Low risk: Alvarado score 1-4
- Intermediate risk: Alvarado score 5-6
- High risk: Alvarado score 7-10
- An Alvarado score of 7 or more was recommended for any appendectomy diagnosis.

Statistical analyses were performed with Statistical Package for Social Sciences (SPSS) computer program (SPSS 15 for Windows, SPSS Inc., Chicago, Illinois, USA). Results of the pathologic examination were considered as the gold standard for Alvarado scores, the USG and CT findings. Accordingly, the Alvarado scores, the USG and CT sensitivities, the specificities, positive predictive value (PPV), negative predictive value (NPV), and the accuracy rates were calculated by standard methods.

The limitations of the study
Factors such as being a retrospective study, low number of patients, physical examinations was conducted by different due to the physician reports of USG and CT being made by several radiologists with different experiences, and lack of communication between the clinician and the radiologist limited the study.

Results

Seventy-four patients were recruited into the study during the period of study. The mean age of the cases included in the study was 36 ± 17.78; 52 cases were males (70.3%) and 22 were females (29.7%). There were no concomitant disease in the history of 58.5% of the cases, while 2.4% had diabetes, 9.8% had coronary artery disease, 9.8% had hypertension, 2.4% had chronic obstructive pulmonary disease (COPD), 7.3% had familial Mediterranean fever (FMF), 6.1% had a history of previous abdominal surgery, 2.4% were pregnant, and 1.2% had other diseases.

On evaluation of the complaints of the patients on admission to the emergency unit: 57% had abdominal pain, 27.3% had nausea and vomiting, and 15.6% had loss of appetite. The mean temperature of the cases was 36.96 ± 0.80°C, the mean white blood cell count was 12.64 ± 4.36 (range: 3.6-9.6 × 10^3 μ/L) and the mean percentage of neutrophils was 75.91 ± 10.97. Fever was present in 20 cases (27%). In 55 cases, the white blood cell count was high (74.3%), and the white blood cell count was normal in 19 cases (25.7%). In 48 cases (64.9%), the percentage of neutrophils was high and in 26 cases (35.1%), the percentage of neutrophils was normal. The percentage of neutrophils was high in 80% of patients who had raised WBC (55 patients). On evaluation of the physical examination of the cases, 44.6% had right lower quadrant tenderness, 25.9% had guarding on abdominal examination, and 29.5% had local rebound [Table 2].

The results of the abdominal ultrasound and CT scan of the studied patients were shown in Table 3.

According to these results, in all the cases, the sensitivity of USG was determined as 71.2%, specificity as 46.7%, the PPV as 82.2%, and the NPV was found to be 31.8%. The accuracy rate of USG for acute appendicitis was calculated as 65.7%. According to these results, in all

Table 1: The Alvarado scoring system	
Alvarado scores	
White blood cell count≥10,000	2
Right lower quadrant tenderness	2
Migration	1
Right lower quadrant rebound	1
Fever≥37.3°C	1
Nausea and vomiting	1
Loss of appetite	1
Percentage of neutrophils≥70%	1
Total	10

cases, the sensitivity of tomography was found to be 97.2%, the specificity as 62.5%, the PPV as 92.1%, and the NPV was found to be 83.3%. The accuracy rate of CT for acute appendicitis was calculated as 90% [Table 4].

In 36 cases (48.6%), the Alvarado score was found to be higher than 7. This score was found to be 5 and 6 in 27 cases (36.5%), while it was found to be lower than 4 in 11 cases (14,9%). The sensitivity of the Alvarado score was calculated as 54%, the specificity as 73.3%, the PPV as 88.2%, and the NPV was calculated as 29.7%. The accurate diagnosis rate (accuracy rate) of the Alvarado score for acute appendicitis was found to be 57.7% [Table 4].

The Alvarado score was also evaluated between the genders. Its sensitivity was found to be 64.3%, specificity as 57.1%, PPV as 90%, NPV as 21.1%, and the accuracy rate was found to be 63.3% in males. In females, its sensitivity was determined as 28.6%, specificity as 75%, PPV as 66.7%, NPV as 37.5%, and the accuracy rate was found to be 45%.

In the USG results of the patients with Alvarado scores 7 and higher than 7, 24 patients (66.7%) showed findings of appendicitis and 10 patients (27.8%) no findings. Two (5.6%) patients did not undergo USG.

In the CT results of the patients with Alvarado scores 7 and higher than 7, 20 patients (55.6%) showed findings of appendicitis. However, 36.1% (13) of the patients had not undergone CT. When we excluded the patients who had not undergone CT, the rate of the patients that had appendicitis findings on CT increased to 87%. The USG and CT findings

of the patients whose Alvarado scores were less than 7 have been illustrated in Table 5.

In our study, 44 cases (59.5%) had undergone open appendectomy and 27 cases (36.5%) had undergone laparoscopic appendectomy, and three cases (4.1%) had been transferred to other centers.

All patients were open appendectomy. The histopathological reports of the cases were as follows: Appendicitis (60.8%), perforated appendicitis (12.2%), lymphoid follicular hyperplasia (8.1%), plastron (periappendiceal abscess) appendicitis (4.1%), normal appendectomy material (4.1%), obliterated appendicitis (1.4%), benign serous cyst (1.4%), oxiuriasis (1.4%), cyst adenoma (1.4%), and chronic inflammatory bowel disease (1.4%). The reports of the three cases (%4.1) could not be accessed. According to the histopathological results, the negative laparotomy rate was determined as 17.8%.

In cases in which the USG, CT and Alvarado scores predictions were compatible with appendicitis, the negative laparotomy rate was determined to be 21% for USG, 8% for CT, and 13% for the Alvarado score.

Discussion

The diagnosis of acute appendicitis in patients presenting with typical clinical findings can be made mostly on the clinical and laboratory findings. Radiation of pain, loss of appetite, nausea, vomiting, and tenderness in the right lower quadrant, fever, and leukocytosis are highly effective and practical criteria for diagnosing acute appendicitis. However, about one-third of the acute appendicitis cases have atypical clinical findings, symptoms, and laboratory findings. In these cases, radiological evaluations are required.[2]

Acute appendicitis is primarily a disease of adolescents and adults and its peak incidence is in the 2nd and 3rd decades of life.[6] In the study conducted by Demircan, *et al.*, with 85 patients, the mean age was 33.5 ± 12.8 years. 55.3% (47) of the patients were males and 44.7% (38) were females. 16.5% (14) of the patients were in the range of 17-20 years of age, 69.4% (59) were in the range of 20-50 years of age, and 14.1% (12) were in the over 50-years age group.[7] In the study conducted by Dikicier, *et al.*, 48% of the cases (*n* = 139) were males, 52% were (148) females and the mean age was 31.5.[8] In our study, the patient age

Table 2: Symptoms, laboratory, and physical examination findings of the patients

Symptoms (%)	
Abdominal pain	57
Nausea and vomiting	27.3
Loss of appetite	15.6
Laboratory (%)	
Leukocytosis≥10000	74.3
Neutrophils≥70%	64.9
Fever≥37.3°C	27
Physical examination (%)	
Right lower quadrant tenderness	44.6
Guarding	25.9
Local rebound	29.5

Table 3: The results of the abdominal ultrasound and CT scan of the study patients

	Appendicitis (%)	Perforated appendicitis (%)	Plastron appendicitis (%)	Retrocecal appendicitis (%)	Other pathologies (%)	Normal (%)	USG and CT not undergone (%)
USG	39 (52.7)	5 (6.8)	1 (1.8)	-	8 (10.8)	17 (23)	4 (5.4)
CT	29 (39.2)	4 (5.4)	2 (2.7)	6 (8.1)	5 (6.8)	1 (1.4)	27 (36.5)

USG=Ultrasonography; CT=Computerized tomography

was in agreement with that of the literature,[6-8] and as it is evaluated for gender, the male gender was higher.

A careful patient history and detailed clinical examination are essential in the diagnosis of acute appendicitis. However, in the laboratory analyses, leukocytosis is a finding which supports the diagnosis of appendicitis.[9] In the study conducted by Demircan, *et al.*, with 85 patients, as 10,000/mm ≥ was taken for the lower limit value for leukocytosis, only 4.7% of the patients (n = 4) had values below this value.[7] Our study, agreed with findings in literature as the white blood cell counts were high in and of the cohort.

The most important initial symptom is pain, which is present in 90-100% of the patients.[10] In a study carried out by Mentes, *et al.*, in 22 cases (27.5%), there was no pain radiation to the right lower quadrant and in 70% of cases, there was right lower quadrant tenderness, which was rebounding in 75% of cases, and the Rovsing's sign was positive 66% of the cases.[11] consistent the find in this study. In our study, clinical examination findings consistent with the literature were present.

In a study carried out by Mentes, *et al.*, in 63.7% of cases, the Alvarado score was higher than seven; in 36.3% of the cases, the Alvarado score was determined as 6 and lower than 6.[11] In our study, the Alvarado score was 7 and above 7 in 48.6% of the cases.

In a study carried out by Chong, *et al.*, regarding the Alvarado score, the sensitivity was determined as 68.3%, the specificity as 87.9%, the PPV as 86.3%, the NPV as 71.4%, and the accuracy rate was determined as 86.5%.[12] In another study carried out with a thousand patients, the sensitivity was determined as 87.41%, the specificity as 74.39%, and the PPV as 83.7%.[13] In our study, we calculated the sensitivity of the Alvarado score as 54%, specificity as 73.3%, PPV as 88.2%, NPV as 29.7%, and the

accuracy rate as 57.7%. Similar to our results, in the study conducted by Jalil, *et al.*, the Alvarado score's sensitivity was reported as 66%, specificity as 81%, PPV as 96%, and NPV were reported as 29%.[14] Again, in another study conducted in 2004, the sensitivity of the Alvarado score was determined as 53.85 and the specificity was determined as 80%. Furthermore, it was reported that the sensitivity and specificity in males (56.4 and 100%) were higher than those in females (48 and 62.5%).[15] The findings of our study were consistent with this study. In other studies, it was reported that the sensitivity and the accuracy rate of the Alvarado score in males were higher than that in females.[15,16] This study is consistent with the finding in the literature, the sensitivity and the accuracy rate of the Alvarado score were higher in males.

The sensitivity of USG in acute appendicitis has been reported as 81-88% and the specificity has been reported as 78-84%.[17] In the study conducted by Wilson, *et al.*, the accurate diagnosis rate of USG was determined as 71-97%, the sensitivity as 76-96%, and the specificity as 47-94%.[18] Orr, *et al.*, found the sensitivity of USG in acute appendicitis as 85% and the specificity as 92%.[19] In the study of Reich, *et al.*, the sensitivity of USG was determined as 68%, and the PPV was determined as 94%.[20] In the prospective study by Poortman, *et al.* followed-up with suspicious acute appendicitis with the sonography and the CT they found out that the sensitivities of CT and sonography were 76 and 79%, respectively; the specificities were 83 and 78%, respectively; and the accuracy rates were 90 and 87%, respectively.[21] While our USG results were consistent with the results of some of the previous studies, they were lower than the results other previous studies. The reason for the lower sensitivity, specificity, and accuracy rate of the USG may be due to the different evaluations of the patients by different radiologists with different experiences.

The sensitivity and the accuracy rates of CT imaging with contrast vary between 96-98% and 93-98%, respectively. The reported sensitivity and accuracy rates for enhanced imaging without contrast varies between 87-90% and 93-97%, respectively.[4] In another study conducted by Caglayan, *et al.*, the sensitivity of CT was reported as 91.2% and the specificity as 83.3%.[22] In our study, while the sensitivity, PPV, NPV, and accuracy rates of CT were found to be in agreement with the previous studies, the specificity was found to be low (62.5%).

Table 4: The statistical evaluation of Alvarado score, USG, and CT findings

	Sensitivity (%)	Specificity (%)	PPD (%)	NPD (%)	Accuracy rate (%)
Alvarado score	54	73.3	88.2	29.7	58
USG	71.2	47	82.2	31.8	66
CT	97.2	62.5	92.1	83.3	90

USG=Ultrasonography; CT=Computerized tomography; NPD=Negative predictive value; PPD=Positive predictive value

Table 5: USG and CT evaluation of patients according to Alvarado scores

Alvarado scores	USG (+) (%)	CT (+) (%)	USG (−) (%)	CT (−) (%)	Patients had not undergone USG (%)	Patients had not undergone CT (%)
≥7	24 (67)	20 (56)	10 (28)	3 (8)	2 (6)	13 (36)
<7	21 (57)	21 (57)	14 (38)	3 (8)	2 (5)	13 (35)

USG=Ultrasonography; CT=Computerized tomography

In the study conducted by Yıldırım, *et al*., in patients with Alvarado scores of 7 and above, the sensitivity of CT was 96.1%, the specificity as 66.6%, the PPV as 98%, the NPV as 50%, and the accuracy rate was 94.5%.[23] In our study, in patients with an Alvarado score of 7 and above, findings of acute appendicitis were determined in 86% of the cases undergoing CT.

In acute appendicitis cases, it is important to reach an early and accurate diagnosis before the complications occur. The objective is to reduce the rate of negative appendectomy without increasing the perforation rate. While early surgical interventions performed to prevent complications have resulted in negative laparotomies in 8-30% of the cases, interventions that are performed late in order to wait for the clinical picture to fully settle, lead to an increase in the rate of perforated appendicitis.[23] Consistent with the literature, in our study, negative laparotomies were determined in 17% of the cases and perforated appendicitis was determined in nine cases (12.7%). In the study of Reich, *et al*., 10% of the cases in whom the USG findings were found to be compatible with appendicitis, resulted in negative laparotomies.[20] In the study conducted by Parks, *et al*., the negative laparotomy rate was reported as 5% for USG, 4.3% for CT, and 12.2% for physical examination.[24] In another study conducted by Pickhardt, *et al*., the negative laparotomy rate for CT was determined to be 7.5%.[25]

In our study, as the negative laparotomy rates were consistent with the literature for CT and the Alvarado scores, the rates were determined to be high for USG. The disadvantages of USG depend on the experience of sonologist, not being performed optimally due to some problems originating from the patient (excess intra-abdominal fat mass, excessive intestinal gas, etc.) or the inability to visualize the appendix.[26] Furthermore, in our hospital, particularly during the night, USG was performed by assistants trained in the radiology department, and the experiences of the radiology assistants being different from each other and the lack adequate of information from the emergency unit clinician may have been the reasons that affected our results.

On review of the literature, it is observed that CT has begun to be used more commonly in the diagnosis of acute appendicitis. Due to the high sensitivity, specificity, and accuracy rates and observed to have reduced the negative laparotomy rates. For this reason, the choice of CT is on an increasing trend in the diagnosis of acute appendicitis. However, being expensive, the time taken for its preparation and imaging, the need to use contrast, and the exposure to ionizing radiation in children and adolescents constitute the limitations for its use as the first choice.[27]

Conclusion

In conclusion, the Alvarado score and USG are not sufficient on their own for making the decision for surgery in patients with acute appendicitis with difficult diagnosis. Compared to these, CT has been determined to have a higher accuracy rate and lower incidence of negative laparotomy. In cases presenting to the emergency department, by taking detailed medical history, performing a careful physical examination and with the laboratory findings, and taking into consideration the possibility of perforated appendicitis as well as of negative laparotomy; CT scan seems to be more effective and efficient investigating acute appendicitis with difficult diagnosis.

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