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Appendicitis scores may be useful in reducing the costs of treatment for right lower quadrant pain

Apandisit skorları, sağ alt kadran ağrısı için tedavi maliyetlerini düşürmede faydalı olabilir

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BACKGROUND

Unnecessary hospital admissions and negative appendectomies increase healthcare costs of patients with right lower quadrant (RLQ) pain. This study aimed to evaluate the impact on the cost of treatment of appendicitis scoring systems.

METHODS

Charts were reviewed of patients admitted to the general surgery ward of our hospital with RLQ pain within a year. Alvarado and Lintula scores were calculated, and a simulation was performed to determine the treatment charges that would have been generated had the scoring recommendations been used for admission and surgical decision-making.

RESULTS

Of the 114 admitted patients, 64 (56%) underwent appendectomy. The rate of negative appendectomy was 17.2%. The overall accuracy rates of the Alvarado and Lintula scores for both 'admit' and 'operate' decision-making were 82.7% and 91.9%, respectively (p=0.102). Total charges for the 114 patients were $39,655. If the Alvarado or Lintula score had been used, the total treatment charges would have been $34,087 and $25,772 (p=0.015 and p=0.000), with negative appendectomy rates of 18.5% and 3.6%, respectively.

CONCLUSION

The implementation of Alvarado and Lintula scores for the decision of hospital admission and appendectomy would have reduced overall treatment charges for acute RLQ pain.

Key Words: Acute appendicitis; Alvarado scores; cost; Lintula scores; score.

AMAÇ

Sağ alt kadran (SAK) ağrısı olan hastaların gereksiz hastane yatışları ve negatif apendektomiler tedavi giderlerini artırır. Bu çalışmada, apandisit skorlama sistemlerinin tedavi maliyetine etkisi değerlendirildi.

GEREÇ VE YÖNTEM

Bir yıl içinde SAK ile hastanemiz genel cerrahi kliniğine kabul edilen hastaların kayıtları incelendi. Alvarado ve Lintula skorları hesaplandı. Hastaneye yatış ve cerrahi tedavi kararında skorlama önerileri kullanılmış olsaydı, tedavi giderlerinin ne olacağını saptamak için bir benzetim çalışması düzenlendi.

BULGULAR

Yüz on dört hastanın 64'üne (%56) apendektomi yapıldı. Negatif apendektomi oranı %17,2 idi. Alvarado ve Lintula skorlarının yatış ve tedavi kararı vermedeki genel doğruluk oranları sırasıyla %82,7 ve %91,9 idi (p=0,102). Hastaların tümü için toplam tedavi maliyeti 39,655 $ idi. Alvarado ve Lintula skorları kullanılmış olsaydı toplam tedavi giderleri sırasıyla 34,087 $ ve 25,772 $ (p=0,015 ve p=0,000); negatif apendektomi oranları %18,5 ve %3,6 olacaktı.

SONUÇ

Alvarado ve Lintula skorlarının hastaneye kabul ve apendektomi kararı için kullanılması akut SAK ağrısı için tedavi giderlerini düşürecektir.

Anahtar Sözcükler: Akut apandisit; Alvarado skoru; maliyet; Lintula skoru; skor.

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Abdominal pain is a common presenting complaint of emergency department (ED) patients who are admitted to general surgery wards. Making an early diagnosis of appendicitis, one of the causes of an acute abdomen, can be difficult. Typical symptoms, signs, and supportive laboratory data are not present in 20-33% of acute abdominal pain patients in whom acute appendicitis is the primary working diagnosis.[1,2] Delay in diagnosis may lead to perforation, periappendicular abscess, wound infection, and intraabdominal adhesions. In the past, it was believed that the most effective way to avoid these complications was to broaden surgical indications at the expense of an increased rate (up to 40%) of negative appendectomy.[3-5] The downsides of this approach are increased hospital bed utilization, higher treatment costs, and loss of productivity.

The Alvarado (Table 1) and Lintula (Table 2) scoring tools were developed in an attempt to assist clinicians in distinguishing acute appendicitis from other causes of abdominal pain, with the aim of reducing the negative appendectomy rate.[6-12] Acute abdominal pain patients with a total score of ≤3 on the Alvarado and ≤15 on the Lintula scales have a lower probability of acute appendicitis and thus do not require hospitalization. Patients with scores of ≥7 and ≥21, respectively, have a higher probability of acute appendicitis requiring emergency appendectomy. Patients with Alvarado scores between 4 and 6 and Lintula scores between 16 and 20 are suspected cases for acute appendicitis; close inpatient follow-up is recommended for this group.[13,14]

We performed a retrospective simulation to determine how charges would have changed if the Alvarado and Lintula appendicitis scoring systems had been used in patients admitted to our department due to right lower quadrant (RLQ) pain. A secondary objective of the study was to determine the diagnostic accuracy of the Alvarado and Lintula scoring systems.

MATERIALS AND METHODS

Charts of patients presenting with RLQ pain to the ED of our hospital between November 2009 and November 2010 and admitted to the general surgery inpatient ward were analyzed. Exclusion criteria included prior appendectomy, concurrent antibiotic therapy, chronic RLQ pain, abdominal trauma, and inguinal hernia. All patients underwent ultrasound (US) examination by a radiology resident in the ED. If the US findings were not consistent with clinical findings, an oral and intravenous (IV) contrast-enhanced multislice computed tomography (CT) was performed. "Clinical decision" was defined as the treatment decision that was reached after the evaluation of medical history, physical examination, laboratory tests, and imaging studies. Patients without a diagnosis of acute appendicitis were admitted for close clinical follow-up; they were kept nil per os (NPO), received maintenance IV fluids, and IV H2-receptor blockers as stress ulcer prophylaxis.

The Alvarado and Lintula scores of the patients were calculated by a staff surgeon, and in case appen-

Table 1. Alvarado score

	Score
Symptoms	
Migratory right iliac fossa pain	1
Anorexia	1
Nausea/vomiting	1
Signs	
Right lower quadrant tenderness	2
Right iliac fossa rebound	1
Elevation of temperature	1
Laboratory findings	
Leukocytosis	2
Left shift (neutrophils)	1
Total score	10

Table 2. Lintula score

	Score
Gender	
Male	2
Female	0
Intensity of pain	
Severe	2
Mild or moderate	0
Migration of pain	
Present	4
Absent	0
Right lower quadrant pain	
Present	4
Absent	0
Vomiting	
Present	2
Absent	0
Body temperature	
≥37.5° C	3
<37.5° C	0
Guarding	
Present	4
Absent	0
Bowel sounds	
Absent, tinkling or high-pitched	4
Normal	0
Rebound tenderness	
Present	7
Absent	0
Total score	32

dectomy had been performed, the pathology report was used as the final diagnosis. Patients whose abdominal pain resolved spontaneously within the first 24 hours of observation, without undergoing appendectomy, were considered not to have acute appendicitis. The hospital charges incurred after evaluation in the ED were calculated from the sum of invoices issued by the government insurance agency to the patient.

Simulation study design

Low-score group (≤3 for Alvarado, ≤15 for Lintula): These patients were considered to probably not have acute appendicitis, and thus discharge home from the ED would be appropriate. As this group would not have been hospitalized, their post-ED charges were taken to be $0. The charges for patients who had low scores but who underwent appendectomy, and in whom the pathology was positive for appendicitis, were used as they were, without adjustment.

Mid-score group (4-6 for Alvarado, 16-20 for Lintula): The treatment costs of those who underwent appendectomy, and in whom the pathology was positive for appendicitis, and of those who were followed closely on the ward without surgery and who had no progression to appendicitis were used as they were, without adjustment. In cases of negative appendectomy, surgery and anesthesia-related charges were subtracted from the patient's total treatment-related bill.

High-score group (≥7 for Alvarado, ≥21 for Lintula): The treatment costs of those who underwent positive or negative appendectomy were used as they were. If the scoring systems had been used for decision-making, the patients whose symptoms spontaneously resolved in this group would have undergone a negative appendectomy. Their treatment costs were assumed to be $454, the average invoice amount of appendectomized patients in this study.

Outcome measures

The sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and diagnostic accuracy rates of the scoring systems and charges for treatment were calculated.

Statistics

Differences between the actual and calculated treatment charges had the Alvarado and Lintula scores been used were analyzed with paired t-testing and 95% confidence intervals. The differences between the sensitivity, specificity, PPV, NPV, and diagnostic accuracy rates of the scoring systems and the actual clinical decision were tested using chi-square testing and 95% confidence intervals. Pearson correlation coefficients were calculated in order to determine the relationship between the Alvarado score, Lintula score, and pathology result.

RESULTS

During the study period, 127 patients with a primary complaint of RLQ pain were evaluated in the ED and referred to the general surgery clinic. Of these, data from the charts of 13 patients were excluded for the following reasons: 1 for having had a prior appendectomy, 6 for concurrent use of antibiotics, 4 for a history of chronic abdominal pain, 1 for a history of abdominal trauma, and 1 for presence of a right inguinal hernia.

In the remaining 114 patients, Alvarado and Lintula scores were calculated. In these patients, US was consistent with acute appendicitis in 56 (49.1%). Only 4 of 22 patients who underwent oral and IV contrast-enhanced CT had a radiologic diagnosis of probable acute appendicitis. Appendectomy was performed in 64 of the 114 patients (56.1%; 33 laparoscopic appendectomies, 31 open appendectomies). Histopathological examination was negative for acute appendicitis in 11 of these 64 patients (17%; 1 of 33 laparoscopic appendectomies, 10 of 31 open appendectomies).

The total bill for the services provided in the general surgery department was $39,655: mean of $454 per patient who underwent appendectomy ($345 in the open appendectomy group and $563 in the laparoscopic appendectomy group) and $208 per patient

Table 3. Sonographic and histopathologic results in 22 patients with right lower quadrant pain who underwent CT in addition to ultrasound scanning

Computed tomography	Ultrasound	Management	No. of patients	Histopathology
Normal	Normal	Observation	14	
		Appendectomy	3	Appendicitis in all 3
	Appendicitis	Observation	0	
		Appendectomy	1	Normal appendix
Appendicitis	Normal	Observation	1	
		Appendectomy	2	Appendicitis in both
	Appendicitis	Observation	0	
		Appendectomy	1	Appendicitis

Table 4. Patient management and histopathological results according to the Alvarado and Lintula scores in 114 patients admitted with right lower quadrant pain

		Appendectomy	
	Observation	Normal appendix	Appendicitis
Alvarado score			
≤3	22	3	2
4-6	19	5	9
≥7	9	3	42
Lintula score			
≤15	46	7	5
16-20	4	2	22
≥21	0	2	26

who was observed on the ward without appendectomy.

Of the 56 patients who had US findings compatible with acute appendicitis, 10 recovered spontaneously during inpatient observation, and 46 underwent appendectomy (6 negative, 40 positive). Of the 58 patients who did not have US findings compatible with acute appendicitis, 40 recovered spontaneously during inpatient observation, and 18 underwent appendectomy (5 negative, 13 positive). The US and histopathology results of 22 patients who were also investigated by CT are summarized in Table 3.

Table 4 lists the distribution of Alvarado and Lintula scores of the patients. Had the Alvarado score been implemented for decision-making, 22 patients with a score of ≤3 would not have been hospitalized, and $7,319 would not have been charged. Eight patients with a score of <7 would not have undergone a negative appendectomy, and $4,017 would not have been charged. Had an Alvarado score of ≥7 been used to operate and perform an appendectomy, nine additional patients would have undergone a negative appendectomy (a negative appendectomy rate of 18.5%), resulting in $4,085 in charges. The actual total charges for these patients, who were in fact observed, was $1,649. Two patients with initial Alvarado scores of ≤3 turned out to have acute appendicitis on their pathology reports, a false-negative rate of 4.5% if the Alvarado score had been used for decision-making. We assumed that the charges of these two patients, who would have presented eventually and undergone emergent appendectomy, would not have changed from their actual charges. Thus, total charges would have been $34,087 instead of 39,655, a 14% difference (p=0.015).

Had the Lintula score been used for decision-making, 58 patients with a score of ≤15 would not have been unnecessarily hospitalized. The treatment cost of these patients was $15,519. Nine patients with scores <21 would not have undergone a negative appendectomy, and $4,516 in charges would have been avoided. All 28 patients with a score of ≥21 were operated, and all but two had a pathology diagnosis of appendicitis. Had the Lintula score been implemented, the negative appendectomy rate would have been 3.6%. Five of 58 patients with a Lintula score <15 turned out to have acute appendicitis, a false-negative rate of 16.1%. We assumed that the charges of these five patients, who would have presented eventually and undergone emergent appendectomy, would not have changed from their actual charges. Charges of patients whose treatment decisions would not have been different if the Lintula score had been used were used as is. Thus, if the Lintula score has been used, total charges would have been $25,772. This figure is significantly lower than actual charges incurred in our patient group (p=0.000).

The sensitivity, specificity, PPV, NPV, and diagnostic accuracy rates of the Alvarado score, Lintula score, and clinical decisions are depicted in Table 5. Sensitivity of the Lintula score was significantly lower than of clinical decision-making (p=0.006), but the difference between the sensitivity of the Alvarado and Lintula scores was not statistically significant (p=0.118). On the other hand, the specificity of the Lintula score was significantly greater than both the Alvarado score and clinical decision-making (p=0.000 and p=0.018, respectively). The difference in specificity between the Alvarado score and clinical decision-making was insignificant (p=0.140). The Alvarado and Lintula scores correlated highly with the histopathological results (Pearson correlation testing, p=0.001 and p=0.000, respectively).

DISCUSSION

The lifelong incidence of acute appendicitis ranges between 5-25%, and appendectomy is the most frequently performed emergency abdominal surgery in the world; in the United States alone, 250,000 appen-

dectomies are performed annually, using one million hospital days and costing 3 billion dollars per year.[15-20] To minimize expenditures while providing the highest quality of service, unnecessary appendectomies should be avoided. Our study demonstrated that common scoring systems used to reduce negative appendectomy rates also significantly reduced treatment charges.

The preoperative diagnosis of acute appendicitis is usually based on clinical findings, but these are only 60-80% accurate due to atypical presentations and the presence of other diseases that cause RLQ pain.[21,22] While US is the most frequently used imaging method to confirm the diagnosis, diagnostic accuracy rates (71% and 97%) are limited by practitioner experience, localization of the appendix, the patient's body mass index, and density of bowel gases.[23-25] CT is a more reliable imaging method for diagnosing acute appendicitis, having a diagnostic accuracy rate of 93-98%.[26] The training and experience of the radiologist significantly affects the accuracy of CT imaging.[27] On the other hand, CT has disadvantages such as contrast-related complications, exposure to ionizing radiation, and high costs. Therefore, US is the preferred imaging modality in pregnant and breastfeeding women, as well as in children.[28] For these reasons, US and CT should be considered complementary techniques, rather than rivals. In SCOAP (Surgical Care and Outcomes Assessment Program), the prevalence of negative appendectomy was found to be higher in patients with conflicting US/CT findings.[29] In our series, the diagnostic accuracy of CT (74.6%) was lower than is commonly reported in the literature, probably due to the fact that radiology residents were reading the emergency CT scans. In addition, CT scanning was performed in only a small proportion of our patients, making meaningful statistical comparisons of the CT results with other parameters impossible.

In our patients, a diagnostic accuracy rate of 90.4% was achieved by clinical examination aided by laboratory and imaging findings. In 1986, when Alvarado proposed a scoring system for the early diagnosis of acute appendicitis, CT and US imaging were not commonly used.[6] In subsequent years, others developed scoring systems based on symptoms as well as associated clinical and laboratory findings.[7-12] The sensitivity, specificity, and diagnostic accuracy of the Alvarado score were reported to be between 84.2-92%, 66.7-91.2%, and 87-92%, respectively.[30-33] The sensitivity, specificity, and diagnostic accuracy of the Lintula score in adults are reported to be 87%, 98%, and 91%, respectively.[14] All three articles found through a PubMed-based literature research on the Lintula scoring system are written by Lintula et al.[7,14,34] According to the results of the present study, the diagnostic accuracy of the Alvarado and Lintula scoring systems in our patients was consistent with the existing literature. We found the specificity of the Lintula score to be very high; thus, had the Lintula score been used for decision-making, our negative appendectomy rates would have been significantly lower.

The Alvarado score has been found to be most accurate in men and children.[35] Having used a modified Alvarado score, Kanumba et al.[36] found sensitivity, specificity, and diagnostic accuracy rates to be different for men and women (95.8%, 92.9%, and 91.5% versus 88.3%, 89.7% and 87.6%, respectively). In the Lintula scoring system, however, the sex of the patient is considered a separate parameter. In our patients, only two women had a Lintula score of ≥21; thus, subgroup analyses by sexes were not performed.

We found high NPVs for the Alvarado and Lintula scoring systems (91.4% and 92.6%, respectively), which means a low false-negativity rate in patients with a low score. Therefore, imaging of patients with a low appendicitis score is not recommended. Supporting this, McKay and Shepherd[13] reported that CT imaging in 52 out of the 55 patients with an Alvarado score of ≤3 was negative (94.5%), and the incidence of delayed presentation of acute appendicitis was only 3.6%. They even argued that because the incidence of acute appendicitis in patients with an Alvarado score of ≥7 was 77.7%, these patients should be referred directly to surgery without CT imaging in the ED.

Although acute appendicitis is considered to result from progressive inflammation, spontaneous resolu-

Table 5. The sensitivity, specificity, positive predictive value, negative predictive value and diagnostic accuracy rates of the Alvarado and Lintula scores and clinical decision in patients with right lower quadrant pain

	Alvarado	Lintula	Clinical decision	*p*
Sensitivity (%)	95.5	83.9	100	0.007
Specificity (%)	67.6	96.4	82.0	0.001
Positive predictive value (%)	77.8	92.9	82.8	0.228
Negative predictive value (%)	92.6	91.4	100	0.111
Diagnostic accuracy (%)	82.7	91.9	90.4	0.133

tion has also been reported.[37-40] Our assumption that spontaneously resolving cases were not true acute appendicitis may be criticized. However, the incidence of spontaneously healing acute appendicitis is not known. Scoring of patients with RLQ pain can be repeated during active observation while patients are worsening or improving clinically; symptoms and signs resolve completely in some patients.[41]

In this retrospective study, both the Alvarado and Lintula scoring systems had high diagnostic accuracy rates for acute appendicitis. Treatment charges would have been significantly lower had these scores been utilized for decision-making in patients with acute RLQ pain.

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