ORIGINAL ARTICLE

A prospective clinical study of the effects of the physical features of the appendix on perforation

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ABSTRACT

BACKGROUND: Acute appendicitis (AA) is one of the most common surgical emergencies, whosepostoperative morbidity and mortality increase significantly when the appendix perforates. The identification of factors that lead to perforation in these patients might effectively reduce morbidity. In this study, factors associated with perforation in AA were examined.

METHODS: The study included sixty patients divided into equal non-perforated and perforated groups. Preoperative body mass index (BMI) and prehospital delay of the patients, the appendix location, presence of fluid or abscesses during surgery, and the appendix wall thickness, root and end diameters, and length in the surgery specimen were compared.

RESULTS: The patients were comprised of forty males and 20 females, with a median age of 27 (range 16–84) years. BMI was significantly higher in the perforated group than the non-perforated group (p=0.039). There was no difference between the groups in terms of the presence of fluid (p=0.792); the presence of abscess was higher in the perforated group (p=0.017). The most common location of the appendix was retrocecal in the perforated group (p=0.007). While there was no difference in the appendix end diameter, root diameter was significantly higher in the perforated group (p=0.041), as were wall thickness (p<0.001) and appendix length (p=0.037).

CONCLUSION: BMI, prehospital delay, a retrocecally positioned appendix, presence of an abscess, and appendix wall thickness, root diameter, and length are risk factors for perforation in AA.

Key words: Appendectomy; perforated appendicitis; risk factors.

INTRODUCTION

Acute appendicitis (AA) is one of the most common reasons for emergency surgery, with approximately 280,000 appendectomies performed each year in the United States.[1–3] The incidence of perforated or gangrenous appendicitis remains high (28–29%).[4,5]

Although the appropriateness of non-surgical treatment for AA is debated, appendectomy is the gold-standard treatment because it is generally assumed that untreated appendicitis will eventually perforate after the appendix has become inflamed.[6] If AA is diagnosed and treated early, recovery time and process remain normal. However, a delay in diagnosis and surgical intervention leads to an increased rate of perforation, longer hospital stay, and increased costs, mortality, and morbidity.[7]

The diagnosis of complicated appendicitis depends on subjective criteria, such as the symptom onset, type of pain, and physical examination. There is a need for objective tests for a definite diagnosis. Despite the use of a variety of objective diagnostic methods, such as radiological imaging, laboratory tests, and scoring systems, in the diagnosis of complicated appendicitis and studies[8–11] of factors affecting the risk of perforation in AA, such as body mass index (BMI), gender, age, season, and time to appendectomy, no comprehensive study has examined the risk factors directly related to perforation. Therefore, we investigated the factors associated with perforation in AA, such as BMI, the physical parameters and location of the appendix and time to operation.

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MATERIALS AND METHODS

Study Groups and Design

This prospective study was conducted from 1 February 2014 to 30 November 2014 in the general surgery and emergency medicine departments of an urban hospital, after being approved by the Regional Ethics Review Committee (Abant İzzet Baysal University Clinical Research Ethics Committee Approval on 10/02/2014 approval no. 2013/46-32). Informed consent was obtained from all patients.

The study enrolled sixty patients operated on for AA and diagnosed with AA histopathologically. The number of patients in the groups was calculated using power analysis and was distributed evenly. The sample size was determined to be thirty patients per group with a power of 0.9 and 95% confidence interval. Patients were divided into non-perforated (n=30) and perforated (n=30) groups. When thirty patients were enrolled in the non-perforated group, patient enrollment in that group was stopped. Subsequently, patients were accepted only for the perforated group until thirty patients were also enrolled.

Patients were excluded if one of the following criteria were present: younger than 16 years (no upper age limit), pregnancy, patients with gastrointestinal malignancies, and perforated appendix induced by trauma.

Patients with a diagnosis of AA based on history, physical examination, laboratory tests, and imaging methods were operated on. Antibiotics were administered at the beginning of surgery. The choice of surgical procedure was left to the surgeon. Laparoscopic appendectomies were performed using the standard three-port technique and conventional appendectomies were performed using the McBurney incision.

The time to the diagnosis of AA from the onset of complaints and the BMI of patients were calculated preoperatively. Appendix location (retrocecal, laterocecal, antececal, or mediocecal) and the presence of fluid or abscesses were assessed intraoperatively. Appendix wall thickness, root and end diameters, and length were measured on the surgical specimen. In addition, appendix diameter at the perforation was measured in the perforated group. Finally, all appendectomy specimens were evaluated histopathologically. The criterion for histological AA was infiltration of the muscularis propria with polymorphonuclear cells. Patients with histopathological non-acute appendicitis were excluded from the study.

Laboratory Analysis

A complete blood count analysis was done and C-reactive protein (CRP) levels were measured using venous blood samples with automated analyzers. Normal values were determined based on reference values accepted by hematology laboratories.

Statistical Analysis

Data were analyzed using SPSS (Statistical Package for Social Science) for Windows 15.0 package program. Data normality was tested by one-sample Kolmogorov-Smirnov test. Continuous variables were given as mean± standard deviation, and

Table 1. The analysis of demographic features of groups

	Nonperforated group (n=30)	Perforated group (n=30)	Overall (n=60)	p
Age (years)	23.5 (16–84)	31 (16–69)	27 (16–84)	0.366
Gender				
Male	20 (50%)	20 (50%)	40	
Female	10 (50%)	10 (50%)	20	
Body mass index (kg/cm^2)	22.87±4.07	25.09±4.06	23.98±4.18	0.039
Prehospital delay (hr)*	25.60±10.26	34.70±14.53	30.15±13.28	0.015

*Duration from the onset of symptoms to operation time.

Table 2. Comparison of laboratory parameters of groups

	Nonperforated group (n=30)	Perforated group (n=30)	Overall (n=60)	p
White blood count (x10^9/L)	13.27±3.66	14.03±3.63	13.78±3.65	0.279
Neutrophilia (%)	79.28±7.54	80.94±7.75	80.11±7.62	0.406
C-reactive protein (mg/dL)	0.40 (0.10–13.60)	4.20 (0.10–44.10)	1.25 (0.10–44.10)	<0.001

Table 3. The distribution of the features identified in the operation

	Nonperforated group (n=30)		Perforated group (n=30)		Overall (n=60)	p
	n	%	n	%	n	
Presence of abscess						0.017
Yes	3	20	12	80	15	
No	27	60	18	40	45	
Presence of fluid						0.792
Yes	11	45.8	13	54.2	24	
No	19	52.8	17	47.2	36	
Localization of appendix						0.007
Retrocecal	8	27.6	21	72.4	29	
Laterocecal	3	75	1	25	4	
Antececal	12	66.7	6	33.3	18	
Mediocecal	7	77.8	2	22.2	9	

were compared with One-Way ANOVA or Kruskal Wallis variance analysis. When p value was significant, Mann-Whitney U multi variance analysis was used to detect the group creating the difference. Non-continuous variables were given as median (min-max), and were compared using Chi-Square test. A p value <0.05 was considered statistically significant.

RESULTS

Thirty patients with AA and thirty with perforated AA were evaluated. The demographic characteristics of the groups are shown in Table 1. The patients included forty (66.6%) males and twenty (33.3%) females with a median age of 27 (range 16–84) years. There was no difference in gender and mean age between the groups. BMI was significantly (p=0.039) higher in the perforated group than the non-perforated group. Prehospital delay was significantly (p=0.015) longer in the perforated group (Fig. 1).

Laboratory values of the groups are summarized in Table 2. While there was no difference in white blood count (WBC) and percent neutrophils, CRP level was significantly (p<0.001) higher in the perforated group (Fig. 2).

According to the data obtained during surgery, abscesses were more frequent in the perforated group (p=0.017) while there was no difference between the groups in terms of the presence of fluid (p=0.792). The most common location of the appendix was retrocecal in the perforated group and antececal in the non-perforated group (p=0.007) (Table 3).

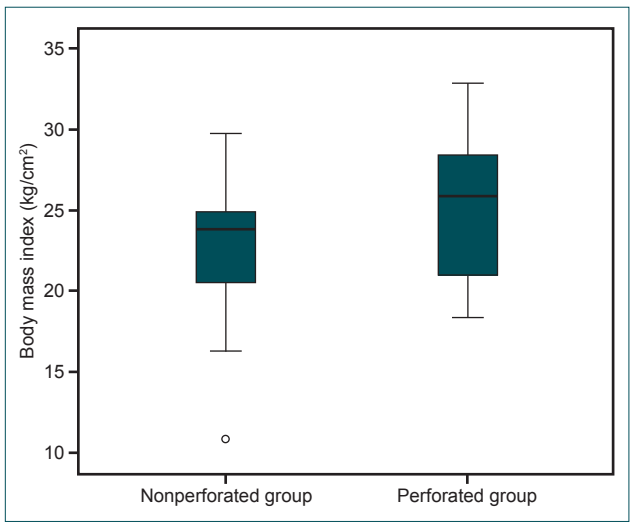

Figure 1. The relation between groups (with and without perforation) and BMI.

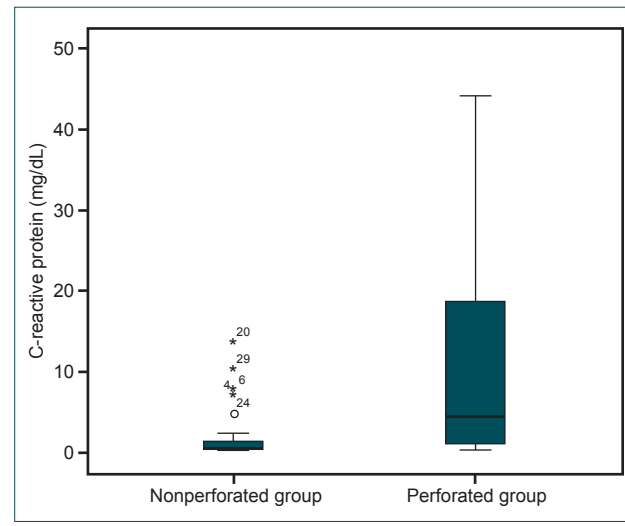

Figure 2. The relation between groups (with and without perforation) and CRP levels.

Table 4. Distributions of the physical quantities of appendix in groups

Measures (mm)	Nonperforated group (n=30)	Perforated group (n=30)	Overall (n=60)	p
Wall thickness	3.00 (1.90–8.00)	4.00 (2.00–10.00)	3.00 (1.90–10.00)	<0.001
Appendix root diameter	7.00 (4.00–15.00)	9.50 (4.00–16.00)	8.00 (4.00–16.00)	0.041
Appendix end diameter	9.00 (5.00–18.00)	10.00 (3.00–40.00)	9.50 (3.00–40.00)	0.225
Appendix length (Mean±SD)	66.53±25.70	80.30±24.14	73.41±25.68	0.037

Table 5. The relationship between the location of perforation and the physical properties of appendix in perforated group

Measures (mm)	Cecum close perforation (n=14)	End close perforation (n=16)	Overall (n=30)	p
Appendix root diameter (Mean±SD)	10.28±3.09	8.87±3.32	9.53±3.25	0.286
Appendix end diameter (Mean±SD)	11.50±8.70	10.31±3.48	10.87±6.41	0.571
Appendix length	70 (35–120)	87.50 (48–130)	85 (35–130)	0.351
Appendix perforated diameter	12.50 (6–80)	13.00 (6–22)	13 (6–80)	0.436

Table 4 and Figure 3 summarize the physical parameters of the appendix in the two groups. Wall thickness (p<0.001) and appendix length (p=0.037) were significantly higher in the perforated group. While there was no difference in the appendix end diameter, the root diameter was significantly higher in the perforated group (p=0.041).

The correlations between the location of the perforation and the physical parameters of the appendix in the perforated group are shown in Table 5. No correlation was found between the distance from the cecum/end to the perforation with root diameter, perforated diameter, or end diameter (r=0.350, p=0.058; r=0.079, p=0.680; and r=0.242, p=0.198, respectively). However, there was a weak positive correlation between the appendix length and the location of the perforation; as the appendix length increased the perforation approached the end of appendix (r=0.369, p=0.045).

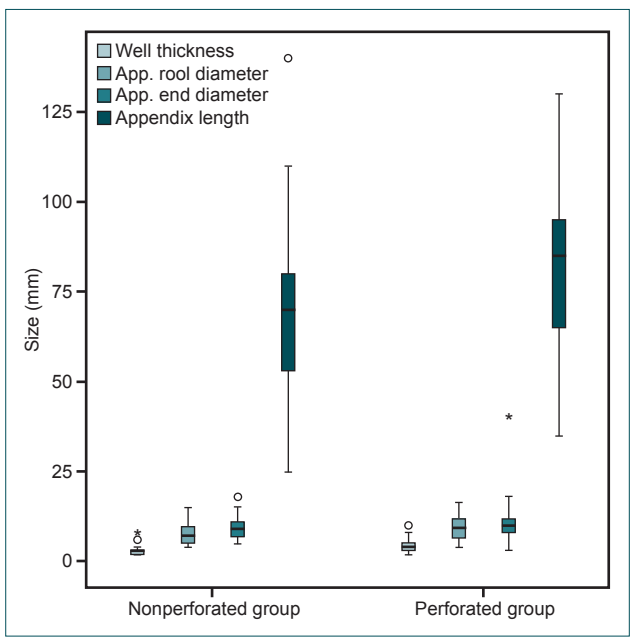

Figure 3. The relation between groups (with and without perforation) and sizes (wall thickness, root and end diameter, length) of appendicitis.

DISCUSSION

This study investigated physical factors associated with perforation in AA. A few studies have examined the factors affecting the risk of perforation in complicated AA. These studies mostly evaluated the time to appendectomy, gender, and age. No comprehensive study has examined the risk factors related to perforation directly.

The lifetime rate of appendectomy is 7%. Despite various advanced laboratory and imaging techniques, the rate of misdiagnosis remains the same (15%), and equals the rate of appendiceal rupture. If diagnosis and surgical intervention are delayed, the perforation, morbidity, and mortality rates all increase considerably in AA.[12,13] The appendiceal perforation rate is higher in the elderly population due to the atypical presentation, presence of comorbid disease, and age-specific physiological changes, such as changes in the colon wall mechanical strength (32–72%).[14–16] Barreto et al.[8] have found that male sex and being older than 60 are significantly associated with a risk of perforation. Augustin et al.[17] have obtained the same results in patients older than 50. Similarly, Sulu et al.[18] have found that the perforation rate is higher in elderly patients. In the present study, sex distributions and

mean age of the patients in the two groups were similar and these were not risk factors for perforation (p=0.366 for age, p=1.000 for sex).

Another parameter that is believed to be associated with appendix perforation is BMI. The diagnosis of AA in obese patients is difficult and the misdiagnosis rate is high due to clinical challenges related to increased BMI, such as decreased mobility, increased fat in the abdominal wall, and an altered response to stress.[19,20] In this study, BMI was higher in the perforated group than in the non-perforated group (p=0.039). The timing of appendectomy is one of the most-studied topics. It is believed that a delay in the surgical removal of the inflamed appendix will result in perforation. Bickell et al.[21] have reported that the risk for developing a perforated appendix is high when the period from the onset of symptoms to surgery exceeds 36 h. In a study of an elderly population, Omari et al.[14] have reported that pre-hospital delay is higher in the perforated group (p<0.0001). In contrast, Drake et al.[9] have found no relationship between the time to treatment and perforation. In our study,pre-hospital delay was higher in the perforated group (p=0.015).

Leukocytosis, neutrophilia, and CRP are important diagnostic markers in AA. Interestingly, the combined use of the three markers improves the sensitivity to 97–100% for the diagnosis of AA. CRP is most likely to be elevated in appendicitis if symptoms are present for more than 12 h.[22] Panagiotopoulou et al.[23] have found that CRP has the highest diagnostic accuracy for perforated appendicitis. Similarly, Moon et al.[11] have reported a significantly elevated CRP in complicated appendicitis. In the present study, CRP levels were markedly higher in the perforated group (p<0.001). In contrast, no relationships between WBC count or neutrophilia and perforation were seen although the levels of both were higher than the reported cut-off values.

Abdominal ultrasonography (US) and computed tomography (CT) are the most common methods used in the diagnosis of AA. Although operator skill is an important factor in all US examinations, its accuracy rates vary. In experienced hands, US has sensitivities of 75–90%, specificities of 86–95%, accuracies of 87–96%, positive predictive values of 91–94%, and negative predictive values of 89–97% for the diagnosis of AA. Abdominal CT complements US and is recommended whenever US results are suboptimal. Its accuracy rates vary according to the appendix diameter. Helical CT has sensitivities of 90–98%, specificities of 91–98%, accuracies of 94–98%, positive predictive values of 92–98%, and negative predictive values of 95–98% for the diagnosis of AA.[22] In a study evaluating the usefulness of CT findings for differentiating perforated from non-perforated appendicitis, Suthikeeree et al.[24] have found that an abscess, extra-luminal appendicolith, and extra-luminal air have the highest specificities for perforated appendicitis, at 95.24%, 100%, and 95.24%, respectively. Tsuboi et al.[25] have found that multi-detector row CT allows an accurate (96.1%) diagnosis of appendiceal perforation when a defect is seen in the contrast-enhanced appendiceal wall. As noted in previous studies, the appendiceal transverse diameter and wall thickness have been evaluated in all imaging methods, while very few studies have examined the relationship between appendix perforation and position. Sheu et al.[16] have found that a retrocecally positioned appendix is a risk factor for perforation of the appendix (OR 1.93, CI 1.15–3.24). In the present study, we were unable to evaluate the imaging methods because of inadequate and inappropriate radiological techniques. We detected significant differences between groups in terms of the presence of an abscess (p=0.017) and retrocecally positioned appendix (p=0.007). We found that the rate of perforation of the appendix increased with appendix length. While we found no difference between groups according to the appendix end diameter, the appendix root diameter was greater in the perforated group (p=0.041). In addition, comparing the location of the perforation and the physical properties of the appendix in the perforated group, we found no correlation between the distance from the cecum or to the perforation with root diameter, perforated diameter, or end diameter; however, there was a weak correlation between the appendix length and the location of perforation (p=0.045, r=0.369).

In summary, BMI, prehospital delay, elevated CRP, a retrocecally positioned appendix, the presence of an abscess, and appendix wall thickness, root diameter, and length are risk factors for perforation in AA. The first four parameters are evaluated preoperatively, and the others intraoperatively. Further research should verify our findings and seek preoperatively diagnostic methods for evaluating intraoperative parameters.

Notes: The English in this document has been checked by at least two professional editors, both native speakers of English. For a certificate, please see:
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Conflict of interest: None declared.

REFERENCES

1. Bergeron E, Richer B, Gharib R, Giard A. Appendicitis is a place for clinical judgement. Am J Surg 1999;177:460–2. CrossRef
2. Adesunkanmi AR, Ogunrombi O. Unusual causes of acute abdomen in a Nigerian hospital. West Afr J Med 2003;22:264–6.
3. National Center for Health Statistics. Ambulatory and Inpatient Procedures in the United States, 1996. National Center for Health Statistics Series 13, No. 139. 2004.
4. Cueto J, D'Allemagne B, Vázquez-Frias JA, Gomez S, Delgado F, Trullenque L, et al. Morbidity of laparoscopic surgery for complicated appendicitis: an international study. Surg Endosc 2006;20:717–20. CrossRef
5. Yaghoubian A, de Virgilio C, Lee SL. Appendicitis outcomes are better at resident teaching institutions: a multi-institutional analysis. Am J Surg 2010;200:810–3. CrossRef

6. Fitz RH. Perforating inflammation of the vermiform appendix with special reference to its early diagnosis and treatment. Trans Assoc Am Physicians 1886;1:107–44.
7. Kim JI, Seong MK, Lee KY. Preoperative prediction of acute perforative and gangrenous appendicitis by clinical features of pa¬tients. J Korean Surg Soc 1993;44:1048–60.
8. Barreto SG, Travers E, Thomas T, Mackillop C, Tiong L, Lorimer M, et al. Acute perforated appendicitis: an analysis of risk factors to guide surgical decision making. Indian J Med Sci 2010;64:58–65. CrossRef
9. Drake FT, Mottey NE, Farrokhi ET, Florence MG, Johnson MG, Mock C, et al. Time to appendectomy and risk of perforation in acute appendicitis. JAMA Surg 2014;149:837–44. CrossRef
10. Ramos CT, Nieves-Plaza M. The association of body mass index and perforation of the appendix in Puerto Rican children. J Health Care Poor Underserved 2012;23:376–85. CrossRef
11. Moon HM, Park BS, Moon DJ. Diagnostic Value of C-reactive Protein in Complicated Appendicitis. J Korean Soc Coloproctol 2011;27:122–6.
12. Körner H, Söndenaa K, Söreide JA, Andersen E, Nysted A, Lende TH, et al. Incidence of acute nonperforated and perforated appendicitis: age-specific and sex-specific analysis. World J Surg 1997;21:313–7. CrossRef
13. Graff L, Russell J, Seashore J, Tate J, Elwell A, Prete M, et al. False-negative and false-positive errors in abdominal pain evaluation: failure to diagnose acute appendicitis and unnecessary surgery. Acad Emerg Med 2000;7:1244–55. CrossRef
14. Omari AH, Khammash MR, Qasaimeh GR, Shammari AK, Yaseen MK, Hammori SK. Acute appendicitis in the elderly: risk factors for perforation. World J Emerg Surg 2014;9:6. CrossRef
15. Lee JF, Leow CK, Lau WY. Appendicitis in the elderly. Aust N Z J Surg 2000;70:593–6. CrossRef
16. Sheu BF, Chiu TF, Chen JC, Tung MS, Chang MW, Young YR. Risk factors associated with perforated appendicitis in elderly patients presenting with signs and symptoms of acute appendicitis. ANZ J Surg 2007;77:662–6. CrossRef
17. Augustin T, Cagir B, Vandermeer TJ. Characteristics of perforated appendicitis: effect of delay is confounded by age and gender. J Gastrointest Surg 2011;15:1223–31. CrossRef
18. Sulu B, Günerhan Y, Palanci Y, Işler B, Cağlayan K. Epidemiological and demographic features of appendicitis and influences of several environmental factors. Ulus Travma Acil Cerrahi Derg 2010;16:38–42.
19. Krebs NF, Himes JH, Jacobson D, Nicklas TA, Guilday P, Styne D. Assessment of child and adolescent overweight and obesity. Pediatrics 2007;120 Suppl 4:193–228. CrossRef
20. Grimble RF. The true cost of in-patient obesity: impact of obesity on inflammatory stress and morbidity. Proc Nutr Soc 2010;69:511–7. CrossRef
21. Bickell NA, Aufses AH Jr, Rojas M, Bodian C. How time affects the risk of rupture in appendicitis. J Am Coll Surg 2006;202:401–6. CrossRef
22. Petroianu A. Diagnosis of acute appendicitis. Int J Surg 2012;10:115–9.
23. Panagiotopoulou IG, Parashar D, Lin R, Antonowicz S, Wells AD, Bajwa FM, et al. The diagnostic value of white cell count, C-reactive protein and bilirubin in acute appendicitis and its complications. Ann R Coll Surg Engl 2013;95:215–21. CrossRef
24. Suthikeeree W, Lertdomrongdej L, Charoensak A. Diagnostic performance of CT findings in differentiation of perforated from nonperforated appendicitis. J Med Assoc Thai 2010;93:1422–9.
25. Tsuboi M, Takase K, Kaneda I, Ishibashi T, Yamada T, Kitami M, et al. Perforated and nonperforated appendicitis: defect in enhancing appendiceal wall-depiction with multi-detector row CT. Radiology 2008;246:142–7. CrossRef

ORİJİNAL ÇALIŞMA - *ÖZET*

Apendiksin fiziksel özellklerinin perforasyon üzerine etkileri: İleriye yönelik klinik çalışma

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AMAÇ: Akut apandisit (AA) en yaygın görülen cerrahi acillerden birisidir ve apendiks perfore olduğunda ameliyat sonrası morbidite ve mortalite artar. Apendiks perforasyonuna yol açan faktörlerin belirlenmesi morbiditeyi azaltmada etkili olabilir. Biz akut apandisitte perforasyonla ilişkili faktörleri inceledik.

GEREÇ VE YÖNTEM: Bu çalışmada 60 hasta ele alındı ve hastalar eşit sayıda iki gruba ayrıldı: Non-perfore ve perfore grup. Biz, ameliyat öncesi dönemde hastaların vücut kitle indeksini (VKİ) ve başvuru öncesi gecikme zamanını, ameliyat esnasında apendiks pozisyonunu, apse veya sıvı varlığı ile cerrahi spesmende apendiksin duvar kalınlığını, kök ve uç çapı ile uzunluğunu karşılaştırdık.

BULGULAR: Hastaların 40'ı erkek, 20'si kadın olup ortanca yaş 27 idi (min-maks: 16–84). Vücut kitle indeksi perfore grupta non-perfore gruptan belirgin şekilde yüksekti (p=0.039). Sıvı varlığı açısından gruplar arasında fark yok iken, apse varlığı perfore grupta daha yüksekti (p=0.017). Perfore grupta, apendiksin en yaygın görüldüğü pozisyon retroçekaldi (p=0.007). Apendiks uç çapına göre gruplar arasında fark yokken, kök çapı, duvar kalınlığı ve apendiks uzunluğu perfore grupta belirgin olarak daha yüksekti (sırasıyla p=0.041, p<0.001 ve p=0.037).

TARTIŞMA: Vücut kitle indeksi, başvuru öncesi gecikme zamanı, retroçekal yerleşimli apendiks, apse varlığı ile duvar kalınlığı, kök çapı ve apendiks uzunluğu akut apandisitte perforasyonu etkileyen risk faktörleridir.

Anahtar sözcükler: Apendektomi; perfore apandisit; risk faktörleri.

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