





Factors That Influence the Length of Hospital Stay After an Appendectomy

 Burak Yalcin Kara,¹  Yahya Ozel,²  Didem Ertorul,³
 Suleyman Caglar Ertekin⁴

¹Department of General Surgery,
Bahcesehir University, Istanbul,
Türkiye

²Department of General Surgery,
Dogus University, Istanbul, Türkiye

³Department of General Surgery,
Sancaktepe Sehit Prof. Dr. Ilhan Va-
rank Training and Research Hospital,
Istanbul, Türkiye

⁴Department of General Surgery,
Private Clinic, Izmir, Türkiye

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Correspondence: Burak Yalcin Kara,
Bahcesehir University,
Istanbul, Türkiye
E-mail: drburakkara@gmail.com



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ABSTRACT

Objective: Acute appendicitis is a surgical emergency that causes acute abdominal pain. After laparoscopic appendectomy, standard hospital care is nearly 24-h, although some patients need a longer length of hospital stay (LOS). This study aimed to evaluate the factors that influence LOS after appendectomy by examining biochemical and radiologic parameters.

Methods: This study retrospectively analyzed the data of 185 patients who underwent appendectomy in 2020-2024 in our hospital. Patient files were examined, and preoperative biochemical values such as white blood cell count, lymphocyte count, neutrophil count, C reactive protein (CRP) value, and neutrophil-lymphocyte ratio (NLR) were recorded. Preoperative radiologic examinations, appendix diameter, and presence of periappendiceal free fluid were assessed.

Results: A total of 163 patients were in early discharge group, and 22 patients were in late discharge group. The mean age of the patients was 34.5 ± 8.5 years, and 53.5% were male. The mean discharge was 1.8 ± 1.4 days. Lymphocyte count was statistically significantly lower in late discharge group, and NLR, CRP value, and appendix diameter were statistically significantly higher in late discharge group ($p < 0.005$). Multivariate analysis showed a significant independent effect of NLR and CRP values ($p < 0.05$).

Conclusion: Decreased lymphocytes, elevated NLR and CRP values, increased appendix diameter, and presence of periappendiceal free fluid on CT affected patients' LOS after appendectomy. Patients with these risk factors could be preferentially selected for laparoscopic approach, routine drain placement, late start of normal food, planned late discharge time and should be informed about longer hospitalization.

INTRODUCTION

Acute appendicitis (AA) is one of the causes of acute abdomen that requires urgent surgical intervention. The lifetime risk of AA is 7% to 8%, although it is more dominantly seen in males, with a rate of 8.6% to 6.7% in females. In the U.S., appendicitis, and related complications are responsible for 0.6% of all hospitalizations.^[1-3] At the time of diagnosis of AA, in addition to the typical physical examinations, biochemical markers and radiologic examinations are diagnostic tools to decide the correct treatment options. Elevated C-reactive protein (CRP) value, white blood cell (WBC) count, neutrophil count and neutrophil percentage, and neutrophil-lymphocyte ratio (NLR) have been shown to predict the diagnosis of AA in previous studies.^[1,4,5] Notably, computerized tomography (CT) imaging can accurately diagnose AA and identify perforation

in AA with high specificity and sensitivity. The fact that postoperative complication rates of AA are observed at rates of 2% to 23% in studies makes correct diagnosis and treatment algorithms important.^[2]

Laparoscopic appendectomy (LA) or the traditional open surgery approach are the surgical options, and antibiotic therapy is medical management in patients with high risk or comorbidity. With the integration of laparoscopy into surgical life, the most common approach in treatment is LA, which is increasingly applied at a higher rate, approaching nearly 90%.^[1,2,6,7] Nowadays, with minimally invasive technology and a new anesthetic modality, there is a tendency for single-day discharge surgery and hospital stay to decrease. The LA technique enhances shorter length of hospital stay (LOS) by decreasing postoperative pain, nausea, and wound infection rates, providing early ambulation.

This is directly linked to reducing costs and increasing the utilization capacity of potential hospital beds.^[2,3,8] However, rehospitalization of patients is related to intra-abdominal abscesses, ileus due to peritonitis, hematoma in the right lower quadrant, and deep surgical site infections. All of these outcomes cause a longer LOS and higher costs,^[3] as patients require longer hospitalization after appendectomy for further evaluations.

The aim of this study was to evaluate the factors that influence the LOS in patients with AA.

MATERIALS AND METHODS

The study was designed as a retrospective data analysis study. Patients who were diagnosed with AA and underwent surgery in our hospital (private clinic) between January 2020 and January 2024 were included in the study. Patient data were collected and analyzed retrospectively, including patients' age, gender, biochemical values such as preoperative leukocyte count, neutrophil count, neutrophil-lymphocyte ratio (NLR), CRP value, preoperative radiological images including appendicitis diameter, and presence of periappendiceal free fluid in abdomen. In addition, the type of surgeries, including open, laparoscopic, conversion from laparoscopic to open surgery, pathological evaluations, LOS, and need for rehospitalization were recorded from the patient files.

Inclusion and exclusion criteria

Patients who had an appendectomy between January 2020 and January 2024 and patients over 16 years of age were included. We excluded patients who had incidental appendectomy without diagnosis with AA (especially at the time of gynecological operations), lacked data records, or whose data were inaccessible.

A total of 202 patients who underwent appendectomies between January 2020 and January 2024 were evaluated. Four patients were excluded because an appendectomy was performed incidentally during gynecologic surgery. Thirteen patients' data were not collected properly, and 17 patients were excluded. Finally, 185 patients were included in the study (Figure 1).

The patients were divided into two groups: the early discharge group, which had an LOS of under 48 h, and the late discharge group, which had an LOS of over 48 h or re-admission.

Primary outcome and ethical approval

The primary outcome of this study was to evaluate the factors that affect LOS or readmission after appendectomy. Before the study, ethical committee approval was obtained by Training and Research Hospital Ethics Committee (E-46059653-050.99-242070323). Due to the retrospective study design, informed consent was not applicable.

Statistical analysis

Mean, standard deviation, median, lowest, highest, frequen-

cy, and ratio values were used in the descriptive statistics of the data. The distributions of variables were measured by Kolmogorov–Smirnov and Shapiro–Wilk tests. The Mann–Whitney U test was used in the analysis of quantitative independent data. A chi-square test was used to analyze the qualitative independent data. The effect level and cut-off value were investigated using the receiver operating characteristic (ROC) curve. The effect level was investigated using univariate and multivariate logistic regressions. The SPSS 28.0 program was used for the analyses.

Complications

There was no mortality in the study. We observed a 30-day re-admission to the hospital in six patients. One patient needed percutaneous drainage for an abdominal abscess. All the included patients were discharged. No major bleeding or transfusion was seen.

RESULTS

Patient demographical features are shown in Table 1, including age, gender, operation type, radiological features such as appendix diameter and periappendiceal free fluid, biochemical results such as WBC, neutrophil count, lymphocyte count, NLR, CRP value, pathological evaluations, discharge day, and readmissions.

Patient median age was 33 years, with 53.5% of the patients being males. Overall, 96.2% of the surgeries were completed by laparoscopic. The median WBC value was $12.3 \times 10^3 / \mu\text{l}$, lymphocyte value was $1.9 \times 10^3 / \mu\text{l}$, and neutrophil value was $9.7 \times 10^3 / \mu\text{l}$. The mean NLR value was 6.1 ± 4.4 , and the mean CRP value was $33.4 \pm 54.3 \text{ mg/l}$. Mean discharge day 1.8 ± 1.4 and rate of readmission was

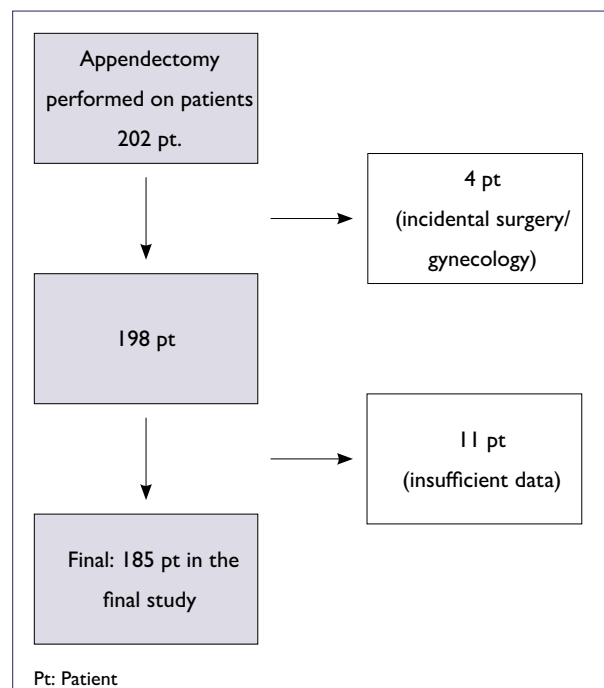


Figure 1. Patient selection data and exclusion process.

Table 1. Patients' demographic features

	Min-Max	Median	Mean±ss/n%
Age	17.0 - 64.0	33.0	34.3±8.5
Gender			
Female			86 46.5%
Male			99 53.5%
Operation type			
Laparoscopic appendectomy			178 96.2%
Conversion laparoscopic to open surgery			2 1.1%
Conventional (open) surgery			5 2.7%
Radiology			
CT			137 74.1%
USG			48 25.9%
WBC	4.9 - 23.5	12.3	12.6±3.9
Neutrophil	2.4 - 19.9	9.3	9.7±3.9
Lymphocyte	0.6 - 5.3	1.8	1.9±0.8
NLR	1.0 - 23.0	5.1	6.1±4.4
CRP	0.7 - 298.9	11.4	33.4±54.3
Appendix diameter (mm)	1.0 - 19.0	11.0	10.9±3.0
Periappendiceal free fluid			
(-)			161 87.0%
(+)			24 13.0%
Pathologic Evaluation			
Acute appendicitis			123 66.5%
Phlegmonous/suppurative appendicitis			32 17.3%
Gangrenous appendicitis			22 11.9%
Lymphoid hyperplasia			6 3.2%
Malignancy			2 1.1%
Discharge day	1.0 - 9.0	1.0	1.8±1.4
Rehospitalization			
(-)			179 96.8%
(+)			6 3.2%

3.2% (6 patients). According to this information, patients were divided into two groups: the early discharge group (under 48h) and the late discharge group (over 48h). The features of these groups are presented in Table 2.

The analysis of the age and gender of the patients did not reveal statistically significant differences between the early discharge groups and the late discharge groups ($p>0.005$). The ratio of conventional appendectomy was significantly higher in the late discharge group than in the early discharge group ($p<0.005$). A comparison of biochemical values showed no statistically significant difference between the two groups regarding WBC count and neutrophil count ($p>0.005$). However, lymphocyte count was statistically significantly lower ($p<0.005$), and NLR and CRP values were statistically significantly higher in the late discharge groups (<0.005). Appendix diameter was significantly statistically higher in late discharge groups, as was the presence of periappendiceal free fluid ($p<0.005$). The rehospitalization ratio was significantly higher in the late discharge group ($p<0.005$) (Table 2).

The results of the univariate and multivariate logistic re-

gression analyses for factors effecting discharge day after appendectomy is shown in Table 3. We observed a significant ($p<0.05$) effect of lymphocyte, NLR, CRP value, appendix diameter, and periappendiceal free fluid in distinguishing between the early and the late discharge groups. In the multivariate model, a significant independent effect of NLR and CRP values was observed ($p<0.05$).

Further, we observed a significant effectiveness of an NLR cut-off value of 6.85 (area under the curve 0.684 [0.555–0.813]) and a CRP cut-off value of 16 mg/L (area under curve 0.745 [0.646–0.843]) in distinguishing between the early discharge and the late discharge group' patients as shown Tables 4 and 5.

DISCUSSION

Appendicitis is one of the most common surgical operations in emergency units and requires hospitalization. With laparoscopy and new anesthetic modalities, a single-day discharge program after an appendectomy is a trend issue. However, some patients need rehospitalization due to complications, such as intra-abdominal abscesses, he-

Table 2. Comparison of the early and late discharge groups

	Discharge day ≤ 2		Discharge day ≥ 3		p
	Mean \pm ss/n%	Median	Mean \pm ss/n%	Median	
Age	34.0 \pm 8.1	33.0	36.0 \pm 10.7	34.0	0.349 ^m
Gender					
Female	72	44.2%	14	63.6%	0.086 ^{X²}
Male	91	55.8%	8	36.4%	
Operation type					
Laparoscopic appendectomy	159	97.5%	19	86.4%	0.037 ^{X²}
Conversion laparoscopic to open surgery	0	0.0%	2	9.1%	
Conventional (open) surgery	4	2.5%	1	4.5%	
Radiology					
BT	117	74.1%	20	90.9%	0.082 ^{X²}
USG	46	29.1%	2	9.1%	
WBC	12.4 \pm 3.8	11.9	13.7 \pm 4.4	13.7	0.223 ^m
Neutrophil	9.5 \pm 3.8	9.1	11.0 \pm 4.2	11.1	0.153 ^m
Lymphocyte	2.0 \pm 0.8	1.9	1.6 \pm 1.0	1.3	0.006 ^m
NLR	5.7 \pm 3.9	4.8	9.1 \pm 6.0	8.2	0.005 ^m
CRP	23.4 \pm 35.5	7.9	107.6 \pm 97.9	73.8	0.000 ^m
Appendix diameter (mm)	10.6 \pm 2.8	10.1	12.9 \pm 3.9	12.5	0.011 ^m
Periappendiceal free fluid					
(-)	150	92.0%	11	50.0%	0.000 ^{X²}
(+)	13	8.0%	11	50.0%	
Pathological evaluation					
Acute appendicitis	109	67.3%	14	63.6%	0.733 ^{X²}
Phlegmonous/Suppurative	29	17.9%	3	13.6%	0.620 ^{X²}
Gangrenous	17	10.5%	5	22.7%	0.097 ^{X²}
Lymphoid Hyperplasia	5	3.1%	0	0.0%	1.000 ^{X²}
Malignancy	2	1.2%	0	0.0%	1.000 ^{X²}
Rehospitalization					
(-)	163	100.0%	16	72.7%	0.000 ^{X²}
(+)	0	0.0%	6	27.3%	

^mMann-Whitney u test/^{X²} Ki-Kare test (Fischer test)

Table 3. Factors that affect discharge day after appendectomy

	Univariate model			Multivariate model		
	OR	95% GA	p	OR	95% GA	p
Lymphocyte (K/uL)	0.453	0.220 – 0.933	0.032			
NLR	1.145	1.052 – 1.247	0.002	1.128	1.020 - 1.246	0.019
CRP (mg/L)	1.020	1.012 – 1.028	0.000	1.020	1.011 - 1.029	0.000
Appendix diameter (mm)	1.269	1.095 – 1.471	0.002			
Periapendiceal free fluid	11.538	4.204 – 31.671	0.000			

Logistic regression (forward LR). NLR: neutrophil-lymphocyte ratio; CRP: C reactive protein.

matomas, ileus with peritonitis, and surgical site infections. Some patients may also need surgical intervention or interventional radiologic procedures. We aimed to evaluate the factors that influenced the longer hospital stay and rehospitalization after an appendectomy by examining the laboratory findings, radiologic examination, and type of

surgical procedure.

A study from Korea suggested that the LOS after an uncomplicated appendectomy was 1.6 to 4.2 days. Another study showed that the mean LOS was 2.1 \pm 0.7 days. Martínez-Pérez et al.^[3] demonstrated that LOS in complicated appendectomy patients was 5 and called prolonged

Table 4. Critical value of neutrophil-lymphocyte ratio

	Area under the curve		95% Confidence interval	p
NLR	0.684		0.555 – 0.813	0.005
NLR 6.85 Cut off	0.676		0.549 – 0.803	0.007
	Early discharge	Late discharge		%
NLR				
≤6.85	124	9	Sensitivity	59.1%
>6.85	39	13	Positive prediction rate	25.0%
			Specificity	76.1%
			Negative prediction rate	93.2%

ROC Curve.

Table 5. Critical value of CRP

	Area under the curve		95% Confidence interval	p
CRP	0.815		0.717 – 0.913	0.000
CRP 16 Cut off	0.745		0.646 – 0.843	0.000
	Early discharge	Late discharge		%
CRP				
≤16	102	3	Sensitivity	86.4%
>16	61	19	Positive prediction rate	23.8%
			Specificity	62.6%
			Negative prediction rate	97.1%

ROC Curve.

LOS more than seven days. Worldwide, the LOS trend after LA tends to be single-day surgery.^[2,3,9,10] The mean LOS in our study was 1.8 ± 1.4 days, which is compatible with the literature.

In the time of diagnosis of AA, biochemical markers are commonly used. In the literature, elevated WBC and neutrophil counts are related to the diagnosis of AA.^[1,4,7,8] In our study, WBC count and neutrophil count were found to be higher in the late discharge group than in the early discharge group, although there were no statistically significant differences between the groups, suggesting that WBC and neutrophil counts cannot be used for the decision of estimated hospitalization time.

A study suggested that a decrease in is associated with perforated appendicitis, whereas an increase in the percentage of lymphocytes may occur with a negative appendectomy.^[9] Another study demonstrated a decreased level of lymphocyte count in complicated appendicitis, but there was no statistical difference.^[1] In our study, we observed that decreased lymphocyte count was statistically significantly lower in the late discharge group ($p < 0.005$). This could be explained by severe inflammation causing a decreased number of lymphocytes, which results in complicated cases and longer hospital stays.

Regarding the NLR, studies have demonstrated that the NLR is related to high inflammation in AA. Yardımcı et al.^[1]

showed that NLR values above 8 were significantly related to perforation and gangrenous appendicitis. Al Amri et al.^[11] showed that the severity of appendicitis could be predicted by NLR. Another study suggested that the critical value of the NLR for diagnosing AA was 3.8, while the NLR in complicated appendicitis was 8.86. A meta-analysis consisting of 13 studies and over 7300 patients demonstrated that NLR was significantly higher in the complicated appendicitis group (10.39) than in the uncomplicated appendicitis group (6.63). A meta-analysis also showed that appendicitis could be distinguished from non-appendicitis cases, with a higher NLR value of 8.04 versus 3.34.^[1,10,11] In our study, NLR in the late discharge group was statistically significantly higher than NLR in the early discharge group ($p < 0.005$). Multivariate analysis showed that NLR could be used as a parameter to estimate hospitalization time pre-operatively. ROC curve analysis showed that the critical NLR value of 6.85 could distinguish between the early discharge group and the late discharge group in our study (Table 4; Figure 2).

One of the most commonly used nonspecific inflammatory markers is CRP, which is used in the diagnosis of an acute abdomen. Elevated CRP levels are strongly associated with the severity of inflammation. Many studies have shown that elevated CRP values predict complicated appendicitis that causes prolonged hospital stays.^[2,4,6,12] A study showed that the percentage of negative appendectomy was 38% if the

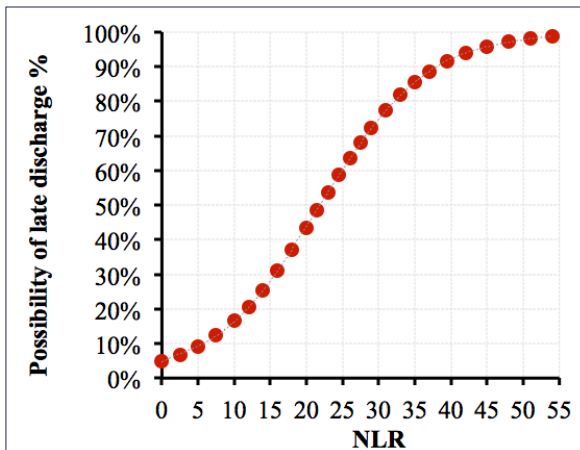


Figure 2. Relationship between NLR and discharge time.

CRP value < 5 mg/l.^[8] Another study suggested that a high CRP level was strongly associated with delayed treatment completion after appendectomy.^[2] A prospective study consisting of 123 patients with LA showed that a CRP value < 18 mg/l was significantly related to LOS of about 24 h.^[12] Our study showed that a higher CRP value predicted a prolonged hospital stay after an appendectomy. There was a statistically significant difference between the early discharge group and the late discharge group regarding CRP levels ($p < 0.005$). Univariate and multivariate analyzes showed that elevated CRP levels were independent risk factors for longer hospital stays, with the ROC curve suggesting a critical CRP level of 16 mg/l (Table 5; Figure 3).

Current methods for evaluating abdominal pain include CT, an indispensable radiologic evaluation tool. Kim et al.^[13] suggested that independent risk factors on CT for early perforated appendicitis include focal defect in the appendiceal wall, circumferential periappendiceal changes, transverse diameter of the appendix (> 11 mm), and the presence of an appendicolith. By contrast, some studies have shown that maximal appendix diameter does not change the LOS.^[2] In our study, we observed that appendix diameter and the presence of periappendiceal free fluid were statistically significantly related with the late discharge group ($p < 0.005$). The mean diameter of the appendix in patients in the late discharge group was 12.9 ± 3.9 mm.

Around the world, appendectomies are performed laparoscopically to reduce hospital stays, costs, and complications related to surgery. During the COVID-19 pandemic, open surgeries were preferred, especially in patients with suspected COVID-19, until sufficient scientific data were obtained.^[12,14,15] In our study, LA was performed on 96.2% of the patients. Only 2.2% of the patients were treated with traditional open surgery. The reason for this was that laparoscopic surgery was not recommended during the COVID-19 pandemic. Two patients (1.1%) required conversion from laparoscopic to open surgery, which affected their LOS, with statistical significance ($p = 0.037$), consistent with the literature.

In the literature, readmission after an appendectomy differs from 1% to 9.3%. A large meta-analysis consisting of

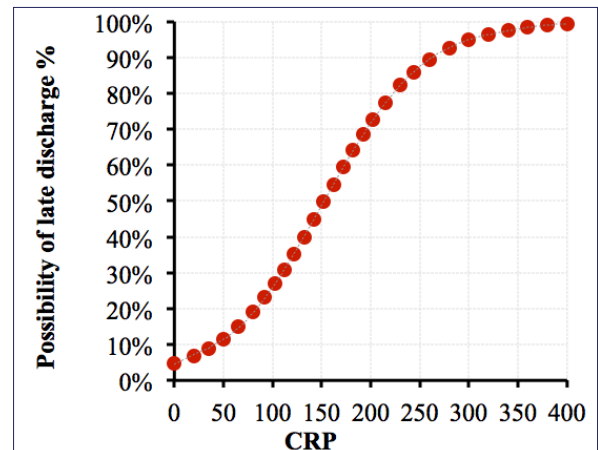


Figure 3. Relationship between CRP and discharge time.

over 836,000 patients showed that the rate of re-admission was 4.3%. In our study, the re-admission rate was 3.2%, which is compatible with the literature.^[16-19]

Our study has several limitations. First, this was a single-center retrospective study. Increasing the number of patients or using multi-center modalities may affect the results. Second, the complication rate of surgeries was very low, which directly affected the LOS. Third, the study design was retrospective, and some patients had to be excluded due to inaccessible data files. Notably, the COVID-19 pandemic negatively affected the patient sample size, as patients who had typical physical examinations with AA may not have presented to the hospital because of fear of the COVID-19 pandemic. Further, some patients also need to be operated on by open traditional surgery instead of the laparoscopic approach.

Conclusion

We showed that a decreased number of lymphocytes, increased NLR and CRP value, increased diameter of appendix, and presence of periappendiceal free fluid on CT were statistically significant findings that affected patients' LOS after appendectomy. Further, an NLR cut-off value > 6.85 and a CRP value > 16 mg/l were independent risk factors for longer hospitalization. Therefore, patients with these risk factors could be preferentially selected for laparoscopic approach, routine drain placement, late start to normal food, and planned late discharge time and should be informed about longer hospitalization.

Ethics Committee Approval

This study approved by the Sancaktepe Sehit Prof. Dr. İlhan Varank Training and Research Hospital Ethics Committee (Date: 17.04.2024, Decision No: 122).

Informed Consent

Retrospective study.

Peer-review

Externally peer-reviewed.

Authorship Contributions

Concept: B.K.; Design: B.K.; Supervision: Y.Ö., S.Ç.E.; Ma-

terials: B.K.; Data: B.K.; Analysis: S.Ç.E.; Literature search: Y.Ö. Writing: B.K.; Critical revision: B.K., D.E.

Conflict of Interest

The authors declare no conflicts of interest.

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Apendektomi Sonrası Hastanede Kalış Süresini Etkileyen Faktörler

Amaç: Akut apandisit, akut karın ağrısına neden olan cerrahi bir acil durumdur. Laparoskopik apendektomiden sonra standart hastane bakımı yaklaşık 24 saattir, ancak bazı hastaların hastanede daha uzun kalış süresine ihtiyacı vardır. Bu çalışmada apendektomi sonrası hastanede yatış süresini etkileyen faktörlerin biyokimyasal ve radyolojik parametreler incelenerek değerlendirilmesi amaçlandı.

Gereç ve Yöntem: Bu çalışmada Medical Park Pendik Hastanesi'nde 2020-2024 yılları arasında apendektomi yapılan 185 hastanın verileri retrospektif olarak analiz edildi. Hasta dosyaları incelenerek ameliyat öncesi beyaz küre sayısı, lenfosit sayısı, nötrofil sayısı, C reaktif protein (CRP) değeri, nötrofil-lenfosit oranı (NLR) gibi biyokimyasal değerler kaydedildi. Ameliyat öncesi radyolojik incelemeler, apendiks çapı ve periapendikste serbest sıvı varlığı değerlendirildi. Hastaların yatış süreleri incelenerek; hastalar 48-saat ya da daha az yatanlar ve 48-saatten daha uzun yatanlar olarak iki gruba ayrılarak karşılaştırılarak incelendi.

Bulgular: Toplam 185 hasta; 163'ü erken taburculuk grubunda, 22'si geç taburculuk grubunda olmak üzere iki grupta incelendi. Hastaların yaş ortalaması 34.5±8.5 olup %53.5'i erkek cinsiyetti. Ortalama taburculuk süresi 1.8±1.4 gündü. Geç taburcu olan grupta lenfosit sayısı istatistiksel olarak anlamlı derecede düşük bulundu. NLR, CRP değeri ve apendiks çapı ise geç taburcu olan grupta istatistiksel olarak anlamlı derecede yüksekti (p<0.005). Çok değişkenli analiz, NLR ve CRP değerlerinin anlamlı bağımsız etkisini gösterdi (p<0.05).

Sonuç: Çalışmada; lenfositlerin azalması, NLR ve CRP değerlerinin yükselmesi, apendiks çapının artması ve BT'de periapendiks çevresinde serbest sıvı bulunmasının hastaların apendektomi sonrası hastane yatış süresini etkilediği görüldü. Bu risk faktörlerine sahip hastalara; rutin dren yerleştirilmesi, normal gıdaya geç başlanması, taburculuk süresinin geç planlanması ve daha uzun hastanede kalış süresi konusunda bilgilendirilmeleri için öncelikli olarak seçilmelidir.

Anahtar Sözcükler: Apendektomi; CRP değeri; hastanede yatış süresi; nötrofil-lenfosit oranı.