ORIGINAL ARTICLE

Risk factors for conversion from laparoscopic appendectomy to open appendectomy: A retrospective analysis of single-center experience

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ABSTRACT

BACKGROUND: Acute appendicitis (AA) is one of the most common causes of surgical acute abdomen. Currently, laparoscopic appendectomy (LA) is the most frequently preferred surgical approach. As with all laparoscopic procedures, the possibility of conversion to open surgery also exists in LA. This study aims to identify the risk factors associated with conversion to open appendectomy (OA) during the laparoscopic management of AA.

METHODS: This retrospective case-control study included 445 patients who underwent LA for AA between 2018 and 2023. Patients were divided into two groups based on whether conversion to OA was required during the laparoscopic procedure. Preoperative demographic, clinical, and perioperative data were evaluated. Both univariate and multivariate analyses were performed.

RESULTS: The median age of the 445 patients included in the study was 34 years (interquartile range: 25-49). Of these, 58.2% were male. The overall conversion rate to open surgery was 3.8%. In univariate analyses, factors such as age (p=0.002), the American Society of Anesthesiologists (ASA) score (p=0.011), time of arrival at the emergency department (p<0.001), C-reactive protein (CRP) level (p<0.001), amylase level (p=0.012), Malatya Complicated Appendicitis Prediction Score (MCAPS) ≥6 (p<0.001), and presence of complicated appendicitis (p<0.001) were associated with conversion. However, in multivariate analyses, only an MCAPS score of 6 or higher (p=0.034) was identified as an independent risk factor for conversion.

CONCLUSION: Since conversion to OA is sometimes unavoidable in the management of AA, clinicians may benefit from using the easily applicable MCAPS to predict the likelihood of conversion. This scoring system may also assist in considering primary OA when appropriate.

Keywords: Appendectomy; conversion to open surgery; laparoscopic appendectomy; Malatya Complicated Appendicitis Prediction Score.

INTRODUCTION

Acute appendicitis (AA) remains the most common cause of emergency abdominal surgery worldwide. However, a definitive diagnosis is often challenging, and approximately one-quarter of cases present in a complicated state.[1] While non-operative treatments are sometimes considered, the current gold standard for management is either laparoscopic appendectomy (LA) or open appendectomy (OA). In recent years, LA has become the preferred approach over OA due to its advantages, including shorter hospital stays, a lower incidence of surgical site infections, and reduced postoperative pain.[2] Furthermore, LA can be performed even in cases of complicated AA (such as perforation or gangrene), depending on the

Cite this article as: Ceylan C, Elbistan İ, Barut B. Risk factors for conversion from laparoscopic appendectomy to open appendectomy: A retrospective analysis of single-center experience. Ulus Travma Acil Cerrahi Derg 2025;31:365-370.

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Ulus Travma Acil Cerrahi Derg 2025;31(4):365-370 DOI: 10.14744/tjtes.2025.36423
Submitted: 05.09.2024 Revised: 06.02.2025 Accepted: 09.03.2025 Published: 28.03.2025

surgeon's expertise. Conversion rates from LA to OA in acute appendicitis range from 4.1% to 19.2%.[3-4] The most common factors complicating LA and leading to conversion to open surgery include inflammatory adhesions and the retroperitoneal anatomical position of the appendix.[3-5]

This study was designed to predict conversion to open surgery based on clinicopathological findings in patients undergoing LA for AA. It is anticipated that the identified predictive factors will assist clinicians in making informed decisions, including opting for primary OA in patients at higher risk of conversion.

MATERIALS AND METHODS

Patient Selection and Study Design

Data from 445 patients who underwent LA for AA between 2018 and 2023 were retrospectively analyzed using the hospital's patient database. Patients who underwent OA, were under 18 years of age, or were diagnosed with appendiceal malignancy were excluded from the study. Patients were divided into two groups based on whether conversion to OA occurred during LA. The analysis included preoperative demographic data (age, gender), clinical data [interval between symptom onset and arrival at the emergency department (ED), leukocyte count (103/μL), platelet count (103/μL), C-reactive protein (CRP) (mg/dL), total bilirubin (mg/dL), amylase (U/L), sodium (mmol/L), appendix diameter (mm)], the Malatya Complicated Appendicitis Prediction Score (MCAPS), and perioperative findings (presence of abscess or perforated appendicitis).

The study was approved by İnönü University Scientific Research and Publication Ethics Committee on July 16, 2024, under reference number 2024/6225.

Patient Management and Surgical Technique

Patients diagnosed with AA, based on clinical history, physical examination findings, and supported by laboratory and imaging studies, received prophylactic antibiotics (1 g cefazolin and 500 mg metronidazole). The surgery was performed by a resident surgeon with at least three years of training, under the supervision of a senior surgeon. In the laparoscopic technique, pneumoperitoneum was established via a suprapubic or subumbilical incision using a Veress needle. With the patient in the left-sided Trendelenburg position, a 5 mm trocar was placed suprapubically, and a 10 mm trocar was inserted through the left lower quadrant, opposite the McBurney point. Following abdominal exploration, the appendix was dissected from the mesoappendix using electrothermal devices. The appendiceal stump was secured with a Hem-o-lok clip, completing the appendectomy. Patients were allowed to resume their diet on the first postoperative day.

Table 1. Malatya complicated appendicitis predictive score (MCAPS)

Age, years	≤ 38	0 point
	>38	1 point
CRP, mg/dL	<3.36	0 point
	≥3.36	3 point
Bilirubin, mg/dL	<0.76	0 point
	≥0.76	1 point
Time before hospital admission, days	<2	0 point
	≥2	5 point

CRP: C-reactive protein.

Definition

The Malatya Complicated Appendicitis Prediction Score was used to assess patients, incorporating parameters such as time to arrival at the ED, CRP, total bilirubin, and age (Table 1).[6] An MCAPS score of 6 or higher was considered indicative of complicated appendicitis. Accordingly, the study population was divided into two groups based on this cut-off value.

Statistical Analysis

The distribution of the data was assessed for normality using the Kolmogorov-Smirnov test. Descriptive statistics were reported, with continuous variables presented as medians and interquartile ranges (IQR), and categorical variables as numbers and percentages. Nonparametric tests, specifically the Mann-Whitney U test, were used for non-normally distributed data. Chi-square analysis was applied to compare categorical variables. Variables found to be statistically significant were further analyzed using prospective selective multivariate logistic regression. The goodness of fit for the model was evaluated using the Hosmer–Lemeshow test. A p value of <0.05 was considered statistically significant. Data analysis was performed using the Statistical Package for the Social Sciences for Windows, version 23 (SPSS Inc., Chicago, IL, USA).

RESULTS

A total of 445 patients were included in the study. The median (IQR) age of the patients was 34 (25-49) years, and 259 (58.2%) were male. Conversion from laparoscopic to open appendectomy was required in 17 patients (3.8%), representing a small proportion of the study population. During exploration, complicated AA was identified in 29.9% of cases, with 28.8% diagnosed as perforated appendicitis and 1.1% as appendicitis with abscess formation. The median operative time was 60 (60-75) minutes, and the median length of hospital stay was 2 (1-3) days. In 33.5% of patients, the MCAPS score was 6 or higher (Table 2).

In terms of demographic data, the median age for patients who required conversion to OA was 53 years (range: 39-63),

Table 2. Analysis table of descriptive data

Variables	Median(IQR)	Count(%)
Age, years	34(25-49)	
Gender		
Female		186(41.8%)
Male		259(58.2%)
ASA ASA1		137(30.8%)
ASA2		238(53.5%)
ASA3		66(14.8%)
ASA4		4(0.9%)
Operation Time, minutes	60(60-75)	
Length of Stay, days	2(1-3)	
MCAPS		
<6		296(66.5%)
6≤		149(33.5%)
Pathologic features		
Simple		312(70.1%)
Gangrenous/Perforated I		28(28.8%)
Plastrone		5(1.1%)
Complicated appendicitis		
Presence		133(29.9%)
Conversion		
Absence		428(96.2%)
Presence		17(3.8%)

IQR: Interquartile range; ASA: American Society of Anesthesiologists; MCAPS: Malatya complicated appendicitis predictive score.

compared to 34 years (range: 25-48) in patients who underwent LA (p=0.002). Among the converted cases, 64.7% were female (p=0.051). A statistically significant difference was also observed in the American Society of Anesthesiologists (ASA) scores between the groups; 35.3% of converted cases were classified as ASA III-IV, compared to 15% in the LA group (p=0.011). Significant differences were further noted between the groups regarding the presence of complicated AA (p<0.001), MCAPS score (p<0.001), time to emergency department presentation (p<0.001), CRP levels (p=0.001), operative time, and length of hospital stay (p<0.001) (Table 3).

In the multivariate analysis, only the MCAPS score was identified as an independent risk factor for conversion to OA (p=0.034; odds ratio [OR]: 4.754 [confidence interval (CI): 1.129-20.04]) (Table 4).

DISCUSSION

Laparoscopic surgery for acute appendectomy is becoming increasingly common, and conversion rates from laparoscopic to open surgery vary depending on multiple factors. Particularly in emergency settings, the success of laparoscopic procedures is significantly influenced by the surgeon's experience and the complexity of the disease.

In our study, although the rate of complicated AA (29.9%) among patients undergoing surgery was notably high, the conversion rate to OA (3.8%) was relatively low. Among preoperative clinical findings, advanced age, delayed presentation to the emergency department, elevated CRP and amylase levels, higher ASA scores, and an MCAPS score of 6 or higher were associated with conversion in univariate analyses. However, in the multivariate analysis, only an MCAPS score of 6 or higher remained an independent risk factor for conversion. We believe that this simple and practical scoring model can assist clinicians in guiding the decision to opt for primary open surgery in patients at higher risk of conversion.

In acute appendicitis, factors such as Black race, older age, male gender, diabetes, and complicated AA have been identified as being associated with an increased likelihood of conversion from laparoscopic to open appendectomy. In a study conducted by Finnerty et al.,[7] it was also demonstrated that patients requiring conversion to OA experienced higher postoperative morbidity and, indirectly, longer hospital stays. The high rate of conversion to OA in cases of complicated AA is thought to be due to perioperative adhesions, widespread peritonitis, and the presence of a plastron. Additionally, LA for complicated appendicitis has been associated with significantly higher postoperative morbidity, such as postoperative paralytic ileus and intra-abdominal abscesses, compared to open surgery.[8] Therefore, models that preoperatively predict complicated AA may also serve as useful tools for anticipating conversion from LA to open surgery. The MCAPS model, developed to predict complicated AA in acute cases, was utilized in our study and was identified as an independent risk factor for conversion to OA.[6]

Several studies have reported that factors such as male gender,[3] an ASA score of 2 or higher,[4,9] leukocytosis,[9-10] limited surgical experience,[5] and advanced age[4,9-10] are associated with an increased risk of conversion to OA. In our study, although higher ASA scores, particularly ASA III and IV, were statistically significant in univariate analyses, they were not found to be significant in multivariate analysis. One possible reason the ASA score is significantly associated with conversion to OA in existing studies is the tendency to avoid prolonged anesthesia and the risk of increased postoperative morbidity in patients with higher anesthetic risk. Additionally, although not statistically significant, our study observed a higher proportion of female patients among those requiring conversion to OA (64.7%), which contrasts with findings in the literature (p=0.051).

One of the components of the MCAPS model used to predict complicated acute appendicitis is age greater than 38 years. In our study, although advanced age was a significant parameter for conversion from laparoscopic appendectomy to open appendectomy in univariate analysis, it was not identified as an independent risk factor in multivariate analysis. A previous

Table 3. Univariate analysis of the groups with and without conversion to open appendectomy

	non Conversion		Conversion		
Variables	**Median(IQR)**	**Count(%)**	**Median(IQR)**	**Count(%)**	**P Value**
Age, years	34(25-48)		53(39-63)		0.002
Gender					
Female		175(40.9%)		11(64.7%)	0.051
Male		253(59.1%)		6(35.3%)	
ASA					
ASA1		136(31.8%)		1(5.9%)	0.011
ASA2		228(53.3)%)		10(58.8%)	
ASA3		61(14.3%)		5(29.4%)	
ASA4		3(0.7%)		1(5.9%)	
ED arrival time, days	1(1-2)		3(2-4)		<0.001
Appendix diameter, mm	10(8-13)		12(10-15)		0.093
WBC, 10^3/uL	12.9(9.9-16.2)		13.3(11.3-16.9)	0.645	
Platelet, 10^3/uL	246(203-293)		254(214-310)		0.648
CRP, mg/dL	1.7(0.3-6.75)		11(2.7-15.1)		0.001
Total bilirubin, mg/dL	0.7(0.5-1.1)		0.8(0.4-1.6)		0.285
Amylase, U/L	59(43.5-76)		44(33-63)		0.012
Sodium, mmol/L	138(136-139)		138(137-140)		0.444
MCAPS					
<6		293(68.5%)		3(17.6%)	<0.001
6≤		135(31.5%)		14(82.4%)	
Operation time, minute	60(60-70)		90(90-134)		<0.001
Pathologic features					
Simple		312(72.9%)		0(0%)	<0.001
Gangrenous/Perforated		115(26.9%)		13(76.5%)	
Plastrone		1(0.2%)		4(23.5%)	
Complicated appendicitis					
Presence		116(27.1%)		17(100%)	<0.001
Length of Stay, days	2(1-3)		5(4-8)		<0.001

IQR: Interquartile range; ASA: American Society of Anesthesiologists; WBC: White blood cells count; CRP: C-reactive protein; MCAPS: Malatya complicated appendicitis predictive score; p<0.05 was considered statistically significant.

study examining postoperative outcomes in patients over 50 years of age undergoing surgery for acute appendicitis emphasized the importance of considering malignancy as a potential etiology, particularly in older age groups, which may contribute to the need for conversion to open appendectomy.[11] In our study, patients with malignancy were excluded, thereby ensuring a more homogeneous study population.

Hyperbilirubinemia has been shown to be indicative of perforated or gangrenous appendicitis,[12] likely due to bacteria translocation into the portal venous system.[13] Additionally, a study by Azılı et al.[4] reported elevated bilirubin levels in patients who underwent conversion to OA. As hyperbilirubinemia is more frequently observed in complicated AA, it may indirectly reflect an increased risk of conversion to OA in these cases.

In cases of AA, CRP has been shown to be directly associated with inflammation and perforation.[14] Consequently, complicated acute appendicitis may indirectly increase the likelihood of conversion from LA to open surgery, with elevated CRP levels potentially serving as a contributing factor in this process. Aydın et al.[15] identified elevated preoperative CRP as a significant predictive factor for conversion to OA. However,

Table 4. Multivariate logistic regression analysis results

	Multivariate Logistic Regression		
Variables	**OR**	**95.0% CI**	**P Value**
ED Time interval, days	1.058	0.912-1.227	0.456
Age, years	1.030	0.995-1.067	0.092
Amylase, U/L	0.979	0.956-1.003	0.079
MCAPS, 6≤	4.754	1.129-20.04	0.034
ASA	1.022	0.263-3.965	0.975
CRP, mg/dL	1.023	0.959-1.091	0.488

OR: Odds ratio; CI: Confidence interval; ED: emergency department; ASA: American Society of Anesthesiologists; CRP: C-reactive protein; MCAPS: Malatya complicated appendicitis predictive score p<0.05 was considered statistically significant.

in our study, although CRP levels were elevated in the univariate analysis, they did not demonstrate a significant association in the multivariate analysis.

It is important to note that the MCAPS model has not yet undergone extensive validation studies to determine whether it serves as a comprehensive tool for predicting complicated acute appendicitis and, by extension, conversion from laparoscopic appendectomy to open surgery. Therefore, its use in this study represents a notable limitation.

CONCLUSION

Although the feasibility of LA for AA has continually improved, conversion to open surgery remains unavoidable in certain cases. This study identifies an MCAPS score of 6 or higher as a significant predictive factor for conversion to OA. We believe that this practical scoring model can assist clinicians in anticipating the likelihood of conversion to OA.

Ethics Committee Approval: This study was approved by the İnönü University Scientific Research and Publication Ethics Committee (Date: 16.07.2024, Decision No: 2024/6225).

Peer-review: Externally peer-reviewed.

Authorship Contributions: Concept: C.C.; Design: C.C., B.B.; Supervision: B.B.; Resource: B.B.; Materials: İ.E.; Data Collection and/or Processing: İ.E.; Analysis and/or Interpretation: C.C.; Literature Review: C.C., İ.E.; Writing: C.C.; Critical Review: B.B.

Conflict of Interest: None declared.

Financial Disclosure: The author declared that this study has received no financial support.

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ORİJİNAL ÇALIŞMA - *ÖZ*

Laparoskopik apendektomiden açık appendektomiye konversiyon için risk faktörleri: Tek merkezli deneyimin retrospektif analizi

AMAÇ: Akut apandisit (AA), cerrahi akut abdomen nedenlerinin başında gelmektedir. Günümüzde laparoskopik apendektomi (LA) en sık tercih edilen cerrahi yöntemdir. Tüm laparoskopik cerrahiler için açığa konversiyon durumu olduğu gibi LA için de bu durum geçerlidir. Bu çalışma ile AA'in laparoskopik cerrahisinde, açığa konversiyon nedenlerini ortaya koymayı amaçladık.
GEREÇ VE YÖNTEM: Retrospektif vaka kontrol çalışması olarak planlanan çalışmaya 2018 ve 2023 yılları arasında akut apandisit nedeniyle laparoskopik appendektomi yapılan 445 hasta alındı. Laparoskopik appendektomi esnasında açığa konverte olan ve olmayan olmak üzere hastalar iki gruba ayrılarak, hastaların preoperatif demografik, klinik ve perioperatif verileri değerlendirildi. Tek değişkenli ve çok değişkenli analizler yapıldı.
BULGULAR: Çalışmaya alınan 445 hastanın yaş median (çeyrekler arası aralık) 34 (25-49) yıldı. Hastaların %58.2'si erkek olmakla birlikte açığa konversiyon oranı %3.8'di. Tek değişkenli analizlerde, yaş (p=0.002), ASA (p=0.011), ED arrival time (p<0.001), CRP (p<0.001), amilaz (p=0.012), 6≤ Malatya komplike apandisit prediktif skor (MKAPS) (p<0.001), komplike apandisit (p<0.001) açığa konversiyona işaret etse de çok değişkenli analizlerde sadece 6≤ MKAPS'in (p=0.034) bağımsız risk faktörüydü.
SONUÇ: Açığa konversiyonun akut apandisitte kaçınılmaz durumlardan biri olduğu düşünülürse, klinisyenlerin kullanılabilirliği kolay olan MKAPS ile açığa konverte olabilecek vakaları tahmin edebilir, hatta primer açık cerrahiyi tercih etmeye yönlenmesine yardımcı olabilir.

Anahtar sözcükler: Appendektomi; açık cerrahiye dönüşüm; laparoskopik apendektomi; Malatya komplike apandisit prediktif skor.

Ulus Travma Acil Cerrahi Derg 2025;31(4):365-370 DOI: 10.14744/tjtes.2025.36423