ORIGINAL ARTICLE

Determination of risk factors for conversion from laparoscopic to open appendectomy in patients with acute appendicitis

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ABSTRACT

BACKGROUND: Acute appendicitis is the most common cause of surgical emergencies. It can be difficult to distinguish cases of acute appendicitis that should be managed by laparoscopic appendectomy (LA) from those that should be managed by open surgery. This study aimed to prevent the inappropriate choice of technique and associated complications by identifying potential risk factors for conversion from laparoscopic to open appendectomy (OA) at the time of initial surgical assessment.

METHODS: This is a retrospective analysis of patients who underwent laparoscopic exploration for acute appendicitis. The study included patients over 18 years of age between January 2016 and July 2021. Patients were divided into two groups according to the surgical approach: those who underwent a LA and those who initially underwent laparoscopic exploration first and then converted to OA. Demographics, perioperative factors, and outcomes were compared between groups.

RESULTS: The study included 634 adults undergoing laparoscopic exploration for an appendectomy. About 80.8% had LA, and 19.2% (n=122) required COA. COA patients' average age was significantly higher than LA patients' (48.5 years vs. 37.8 years, P<0.001). The conversion rate for patients over 65 was 63.8%, compared to 15.6% for those under 65 (P<0.001). COA patients had higher bilirubin levels (36.1% vs. 13.5%, P<0.001), higher American Society of Anesthesiologists (ASA) scores (ASA >2, COA 52.5% vs. LA 7.8%, P<0.001), and a higher need for CT imaging (84.4% vs. 67.6%, P<0.001) than LA patients. An Alvarado score >6 significantly differentiated LA from COA (62.6% vs. 39.4%, P< p<0.001). COA patients experienced significantly increased periods until starting oral intake (31.6 vs. 9.9 h, P<0.001) and higher rates of complicated appendicitis (40.9% vs. 0.6%, P<0.001). After surgery, COA had higher rates of complications compared to LA: surgical site infections (8.2% vs. 2.7%, P=0.004), reoperation (13.1% vs. 0%, P<0.001), hospital readmission (14.7% vs. 2.3%, P<0.001), and mortality (1.6% vs. 0%, P<0.004).

CONCLUSION: Advanced age, especially over 65 years, elevated bilirubin levels, an ASA >2 score, and an increased need for preoperative diagnostics using CT scans were found to be significant predictors of conversion to OA. In the conversion group, operative time, time to oral intake, and the incidence of complicated appendicitis were significantly higher. The conversion group had significantly higher rates of postoperative complications, surgical site infections, hospital readmissions, and mortality. To avoid the increased rate of complications associated with conversion to open surgery, the initial evaluation of a patient with prospective risk factors may be beneficial.

Keywords: Appendectomy; complications; conversion to open; laparoscopic; risk factors.

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INTRODUCTION

Until recently, appendectomy was the only treatment option for appendicitis. Despite the increasing prevalence of non-operative management, it remains the most common emergency procedure.[1] Since the development of laparoscopic appendectomy (LA) in 1983, LA has gained popularity over open appendectomy (OA).[2] LA is favored due to reduced postoperative pain and superior cosmetic results compared to OA.[3-6] However, both methods need to be evaluated based on their respective limitations and advantages. The appropriate surgical treatment option for appendicitis should be determined by evaluating the surgeon's surgical experience, the availability of adequate technical support, patient-related factors, and the presence of previous surgery. Conversion to open surgery may prolong the surgical procedure and increase the risk of complications.[3,7,8] Therefore, we aimed to identify preoperative risk factors predicting the failure of LA.

MATERIALS AND METHODS

This is a retrospective analysis of patients who underwent laparoscopic exploration for acute appendicitis at a single center. The study included patients over 18 years of age between January 2016 and July 2021. Patients were divided into two groups according to surgical method: those who underwent LA and those who initially underwent laparoscopic exploration before converting to OA. Of the 648 patients who underwent laparoscopic exploration for acute appendicitis, 634 patients who met the criteria were included in the study. Patients who underwent an open or interval appendectomy for other surgical reasons were excluded.

Patients were evaluated by physical examination, laboratory tests, and imaging techniques. Blood tests, including a complete blood count and serum biochemistry, were documented with demographic information. Leukocytosis was defined as a white blood cell (WBC) count >12.000×10^6/L. Total bilirubin levels above 1.2 mg/dL were considered elevated. Patients underwent abdominal ultrasonography and/or computed tomography (CT) if clinical suspicion persisted. Perioperative findings, operative time, length of hospital stay, and decision to proceed with open surgery were evaluated. Surgery was performed by an attending surgeon or residents with at least 2 years of surgical training. Patients were also monitored for the development of complications, including surgical site infection, reoperation, hospital readmission, and mortality. Age, sex, American Society of Anesthesiologists (ASA) score, presence of elevated WBC count and bilirubin levels, Alvarado score, need for CT, indications for conversion to OA (COA), postoperative complications, and 30-day mortality were compared between the groups.

Laparoscopic exploration was performed using the three-port technique. Endo-loop was used for the stump closure in LA. Patients in whom the laparoscopic approach was insufficient to perform an appendectomy were evaluated in the conversion to open surgery group. OA was performed with double ligation of the appendiceal base using absorbable sutures. Pathological evaluation of the appendix was a routine procedure. Based on intraoperative findings, a simple or complicated appendicitis diagnosis was made. Complicated appendicitis was defined as perforated appendicitis, periappendicular abscess, or purulent peritonitis. Antibiotic medication, time to oral intake, and length of hospital stay were decided after all evaluations. In cases of complicated appendicitis, antibiotic treatment was continued for 1 week. A routine examination was scheduled on the postoperative day 10. Readmissions, hospitalizations, complications, and reoperations were recorded during the first 30 days of hospitalizations. Mortality was defined as death occurring during the first 30 days of hospitalization. Ethical approval was granted by the ethics committee of our tertiary teaching hospital. Due to the retrospective nature of the study, informed consent to participate was waived.

Descriptive statistics were presented as mean and standard deviation according to the distribution of continuous variables. Categorical variables were presented as numbers and percentages. The Kolmogorov–Smirnov test was used to assess the normal distribution of the numerical variables. The Mann–Whitney U, or student's t-test, was used to compare two independent groups. The Chi-square test was used to compare the differences between categorical variables. Data were analyzed using the Statistical Package for the Social Sciences for Windows, version 22 (Inc., Chicago, IL). A P=0.05 was considered statistically significant.

RESULTS

Six hundred and thirty-four patients underwent laparoscopic exploration due to acute appendicitis between January 2016 and July 2021. The average age of the series was 39.9 years. There were 398 (62.8%) males and 236 (37.2%) females. Most of the patients had noncomplicated appendicitis (n=467, 73.7%). The mean operative time was 53.3 min. Table 1 presents the demographic characteristics, mean age, indications for OA, complications, and mortality rates. The mean length of the hospital stay was 1.9 days. The rate of conversion to open surgery was 19.2% (n=122). Laparoscopic exposure issues due to inadequate appendix visualization due to severe inflammatory adhesions (n=74, 60.7%), appendicular plastron (n=18, 14.8%), base inflammation or necrosis (n=9, 7.4%), cecum damage (n=5, 4.1%), hemorrhage (n=5, 4.1%), and other organ injuries; small bowel and bladder injuries led to COA.

The cohort was divided into two groups. The LA group included 512 (80.8%) patients, and the COA group included 122 patients (19.2%) (Table 2). The average age of patients who underwent LA was 37.8 years, while it was 48.5 years in COA. The average age was significantly higher in COA compared to LA (P<0.001). Furthermore, the conversion rate for patients aged 65 and older was 63.8% (n=30/47), while it was 15.6% (n=92/587) for patients aged 18 to 64 (P<0.001). Hence, there was a significant difference in conversion rates

between those under and over 65 years of age. Most of the patients were males, but gender did not differ significantly between the groups (P>0.05). There was no significant difference in leukocytosis between the groups, but the bilirubin values of more than 1.2 mg/dL were significantly higher in COA compared to LA (36.1% versus 13.5%, P<0.001). The Alvarado score was found to be a statistically significant factor in differentiating LA from COA; 62.6% of LA patients had an Alvarado score>6, compared to 39.4% of COA patients (P<0.001). The ASA score was significantly higher in the COA group than in the LA group. 52.5% of COA patients had an ASA score> 2, compared to 7.8% of LA patients (n=64/122; 40/512, respectively, P<0.001).

The requirement of CT due to suspicion was significantly higher in COA than in LA (84.4% versus 67.6%, and P<0.001). After surgery, the period until the start of oral intake and the rate of complicated appendicitis in terms of gangrenous/perforated and plastron were significantly increased in COA than in LA (31.6 and 9.9 h, P < 0.001; 40.9% and 0.6%, P<0.001, respectively). After surgery, complications such as surgical site infections (COA; 8.2% vs. LA; 2.7%, P=0.004), reoperation rate (COA; 13.1% vs. LA; 0%, P<0.001), readmission to the hospital (COA; 14.7% vs. LA; 2.3%, P<0.001), and mortality rate were higher in COA (COA; 1.6% vs. LA; 0%, P<0.004). However, the rate of intraabdominal abscesses was higher in COA than in LA (COA 0% vs. LA 2.2%, P<0.007).

DISCUSSION

This study aimed to identify the risk factors associated with LA requiring conversion to an open laparotomy. We believe that several factors, including initial patient selection, contributed to the need for COA. Advanced age, especially over 65 years, elevated bilirubin levels, an increasing ASA score, and an increased need for preoperative diagnostic CT scans were found to be significant predictors of COA; however, Alvarado scores above 6 were found to be significant for LA. The conversion group had a significantly longer operative time and time to oral intake, with a higher risk of complicated appendicitis. Significantly higher rates of post-operative complications, such as surgical site infections, hospital readmissions, and mortality, were observed in the group that underwent COA compared to LA. To avoid the increased incidence of complications associated with conversion to open surgery, it may be beneficial to evaluate a patient prospectively for possible risk factors.

Table 1. The characteristics of patients who underwent appendectomy for acute appendicitis

	n=634
Mean age (mean) years	39.9±14.9 (18–94)
Gender	
Female, n, (%)	236 (37.2)
Male, n, (%)	398 (62.8)
Appendicitis findings, n, (%)	
Noncomplicated	467 (73.7)
Complicated	167 (31.3)
Operative time (mean, minutes)	53.3±20.5 (15–210)
The period until the start of meal intake (hours)	14.1±18.7
Rate of conversion to open surgery	122 (19.2)
Causes	74 (60.7)
Inadequate appendix visualization due to severe inflammatory adhesions	18 (14.8)
Appendicular plastron	9 (7.4)
Base inflammation or necrosis	7 (5.7)
Caecum damage	5 (4.1)
Hemorrhage	5 (4.1)
Small bowel injury	2 (1.6)
Bladder injury	2 (1.6)
Length of hospital stay (mean, days)	1.9 (0–25)
Surgical site infection rate, n, (%)	24 (3.7)
Reoperation rate, n, (%)	16 (2.5)
Readmission to hospital, n, (%)	30 (4.7)
Mortality rate, n, (%)	2 (0.3)

Table 2. Patients' characteristics and postoperative outcomes analysis

		LA n 512	COA n 122	P-value
Demographic features	Age, mean (years)	37.8±13.1	48.5±18.7	<0.001
	Age distribution (years), n, (%)			
	18–64	495 (84.4)	92 (15.6)	<0.001
	Over 65	17 (36.2)	30 (63.8)	
	Gender			
	Female, n, (%)	193 (81.3)	43 (18.2)	>0.05
	Male, n, (%)	319 (80.2)	79 (19.8)	
Preoperative evaluations	Presence of leukocytosis	415 (81)	91 (74.5)	0.659
	(WBC >12.000×10^6/L), n, (%)			
	Presence of elevated bilirubin levels	69 (13.5)	44 (36.1)	<0.001
	(Bilirubin >1.2 mg/dL), n, (%)			
	Alvarado score, n, (%)			
	1–4	24 (4.7)	12 (9.8)	<0.001
	5–6	167 (32.7)	62 (50.8)	
	7–8	268 (52.3)	48 (39.4)	
	9–10	53 (10.3)	0 (0)	
	ASA score, n (%)			
	1	120 (23.5)	9 (7.3)	<0.001
	2	352 (68.7)	49 (40.2)	
	3	40 (7.8)	54 (44.3)	
	4	0 (0)	10 (8.2)	
Requirement of CT imaging, n, (%)	346 (67.6)	103 (84.4)	<0.001	
Perioperative features	Operative time (minutes)	48.8±15.3	72.5±27.5	<0.001
	The period until the start of meal intake (hours)	9.9±11.1	31.6±30.4	<0.001
	Pathologic examination, n, (%)			
	Normal/lymphoid hyperplasia	47 (9.2)	1 (0.8)	<0.001
	Simple	406 (85.5)	69 (56.6)	
	Gangrenous/Perforated	59(0.6)	39 (32)	
	Plastron	0	13 (10.7)	
Postoperative complications	Length of hospital stay (mean) days	1.4±1.1	4.1±3.2	<0.001
	Surgical site infection rate, n, (%)	14 (2.7)	10 (8.2)	0.004
	Intraabdominal abscesses, n, (%)	0	3 (2.2)	0.007
	Readmission to hospital, n, (%)	12 (2.3)	18 (14.7)	<0.001
	Reoperation rate, n, (%)	0	16 (13.1)	<0.001
	Mortality rate, n, (%)	0	2 (1.6)	0.004

WBC: White blood cells count; ASA; American Society of Anesthesiologists; CT: Computerized tomography of the abdomen.

COA may be unavoidable during laparoscopic exploration. In our series, inadequate visualization of the appendix due to severe inflammatory adhesions was the most common cause of conversion, and the conversion rate of 19.2% was comparable to recent reports of up to 27%.[3,7,8] However, it may be possible to select the most appropriate approach by assessing the patient's risk factors before surgery. Age>40 years has been reported to be an independent predictor of COA. A number of studies agree that LA can be performed more frequently in the 30s, while the risk of conversion increases after the age of 40.[4,5,9-11] Similar to recent reports, the mean age of patients undergoing LA in our series was 37.8 years, while

the mean age of patients undergoing COA was 48.5 years. Being older than 65 years has also been reported as a risk factor for conversion.[12,11] Our data showed a significant difference in the conversion rates between patients under 65 and those over 65. The conversion rate for patients aged 65 and older was 63.8%, whereas the conversion rate for patients aged 18–64 years was only 15.6%. Male sex is suggested as a risk factor for conversion. Although the male proportion increased in our series, no significant association between the risk of conversion and gender was found.[4,10]

According to a recent review, male gender, advanced age, and an ASA score >2 are thought to be associated with preoperative variables for COA.[4] It is possible to predict perioperative risks using the ASA score, which has also been used as a physical status classification system. The factors that cause an increase in the ASA score may indicate the risk of COA.[1,4,3,7,9,10,12] Our data showed that 52.5% of COA patients had an ASA score>2, compared to 7.8% of LA patients. Therefore, advanced age, age >65 years, and male sex with an increasing ASA score should be evaluated more closely when determining the appendectomy method for conversion risk.

Interestingly, preoperative Alvarado scores >6 helped to predict LA in our series. Similarly, there are studies suggesting that the Alvarado score is not a significant indicator of conversion to open surgery.[13] In our series, 62.6% of LA patients had an Alvarado score>6, compared to 39.4% of COA patients. In fact, physical examination and scoring systems that suggest classical appendicitis may provide early diagnosis and possibly laparoscopic treatment, whereas delayed diagnosis and treatment in cases of perforated appendicitis and appendicular plastron increase the need for open surgery.

According to a study by Emmanuel et al., bilirubin is a specific marker with a high positive predictive value that can be used to assess acute appendicitis. Patients with hyperbilirubinemia are also more likely to develop appendiceal perforation or gangrene.[14] Hyperbilirubinemia may also be caused by an increase in the number of bacteria entering the portal vein.[15] In our study group, elevated bilirubin levels were significantly higher in COA than in LA.[16] Perhaps, the significant relationship between these elevated bilirubin levels and the risk of conversion can predict the severity of appendicitis and severe inflammation, for which the laparoscopic approach is inadequate. However, data on this remarkable finding are limited. We believe that new studies on this topic can help to make effective use of elevated bilirubin.

LA is considered superior due to a lower incidence of wound infection, less pain, and a shorter hospital stay. However, if conversion to open surgery is necessary, the risk of postoperative complications must be considered.[10] According to available reports, COA results in a significant increase in operative time. Although the open approach was superior in terms of a shorter operative time, COA was reported to have a significantly longer operative time. The mean operative time was significantly prolonged in our series, similar to other reports.[3-5,7,9,11] A cohort analysis of risk factors and outcomes associated with conversion to open LA found that COA was associated with a greater likelihood of infectious complications than OA. In addition, COA was associated with a higher risk of infectious and systemic complications than LA.[4,10,12] In our series, complications such as surgical site infection (COA/LA; 8.2% vs. 2.7%) and intra-abdominal abscess (COA/LA; 2.2% vs. 0%) were higher in COA patients compared to LA patients. Readmission to the hospital within 30 days is also more common in COA compared to both LA and OA.[4] Our data showed that re-hospitalization, reoperation, and mortality were significantly higher in COA compared to LA (14.7% vs. 2.3, 13.1% vs. 0%, and 1.6% vs. 0%, respectively). Thus, with the correct planning of the surgical approach, most of the complications can be prevented.

The main significant limitations of this study are that it is retrospective and unicentric. The decision regarding whether to perform primary LA or COA was made by the attending surgeon without regard to any evident criteria. Despite the limitations of our study, it provides important information regarding risk factors for conversion from LA to open surgery.

CONCLUSION

This study identified the risk factors associated with conversion from LA to OA COA. The findings highlight the importance of patient selection and preoperative assessment in determining the appropriate surgical approach for acute appendicitis.

Advanced age, especially over 65 years, elevated bilirubin levels, an increasing ASA score, and the need for preoperative diagnostic CT scans were significant predictors of conversion to open surgery. On the other hand, an Alvarado score above 6 was found to be significant for LA.

This study confirms that LA is the preferred approach due to its advantages, such as a shorter hospital stay, less postoperative pain, and better cosmetic results. However, when conversion to open surgery is required, it is associated with longer operative times and a higher risk of complications, including surgical site infections, re-operation, readmission, and mortality. Future prospective studies may refine our understanding of these risk factors to help surgeons make more informed decisions and optimize patient outcomes in acute appendicitis.

Ethics Committee Approval: This study was approved by the Dışkapı Yıldırım Beyazıt Training and Research Hospital-Ethics Committee (Date: 12.09.2022, Decision No: 146/21).

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ORİJİNAL ÇALIŞMA - *ÖZ*

Akut apandisitli hastalarda laparoskopik apendektomiden açık apendektomiye dönüşüm için risk faktörlerinin belirlenmesi

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AMAÇ: Akut apandisit en yaygın cerrahi acil durum nedenidir. Laparoskopik apendektomi ile tedavi edilmesi gereken akut apandisit vakalarını açık cerrahi ile tedavi edilmesi gereken vakalardan ayırt etmek zor olabilir. Bu çalışmanın amacı, ilk cerrahi değerlendirme sırasında laparoskopik apendektomiden açık apendektomiye dönüşüm için potansiyel risk faktörlerini belirleyerek uygunsuz teknik seçimini ve buna bağlı komplikasyonları önlemektir.

GEREÇ VE YÖNTEM: Bu çalışma, akut apandisit nedeniyle laparoskopik eksplorasyon yapılan hastaların retrospektif bir analizidir. Çalışmaya Ocak 2016 ve Temmuz 2021 tarihleri arasında 18 yaş üstü hastalar dahil edilmiştir. Hastalar cerrahi yaklaşıma göre iki gruba ayrıldı: laparoskopik apendektomi (LA) yapılanlar ve önce laparoskopik eksplorasyon yapılıp daha sonra açık apendektomiye (AAG) geçilen olgular. Gruplar arasında demografik özellikler, perioperatif faktörler ve sonuçlar karşılaştırıldı.

BULGULAR: Çalışmaya apendektomi için laparoskopik eksplorasyon yapılan 634 erişkin dahil edildi. %80.8'sinde LA yapıldı ve %19.2'sinde (n=122) AAG gerekti. AAG hastalarının yaş ortalaması LA hastalarından anlamlı olarak daha yüksekti (48.5 yıla karşı 37.8 yıl, p<0.001). Konversiyon oranı 65 yaş üstü hastalar için %63.8 iken, 65 yaş altı hastalar için %15.6 idi (p<0.001). AAG hastalarda LA hastalarına kıyasla daha yüksek bilirubin düzeyleri (%36.1'e karşı %13.5, p<0.001), daha yüksek ASA skorları (ASA>2, COA %52.5'e karşı %7.8, p<0.001) ve daha yüksek BT görüntüleme ihtiyacı (%84.4'e karşı %67.6, p<0.001) vardı. Alvarado skoru LA'yı AAG 'dan önemli ölçüde ayırmıştır (skor>6 olan %62,6'ya karşı %39.4, p<0.001). AAG hastalarında oral alıma başlayana kadar geçen süre (31.6'ya karşı 9,9 saat, p<0,001) ve komplike apandisit oranları (%40.9'a karşı %0.6, p<0.001) anlamlı derecede yüksekti. Ameliyattan sonra, AAG'da LA'ya kıyasla daha yüksek komplikasyon oranları görüldü: cerrahi alan enfeksiyonları (%8.2'ye karşı %2.7, p=0.004), yeniden ameliyat (%13.1'e karşı %0, p<0.001), hastaneye tekrar yatış (%14.7'ye karşı %2.3, p<0.001) ve mortalite (%1.6'ya karşı %0, p<0.004).

SONUÇ: İleri yaş ve özellikle 65 yaş üstü, yüksek bilirubin düzeyleri, ASA>2 skoru ve BT taraması kullanılarak ameliyat öncesi tanılama ihtiyacının artması, açık apendektomiye geçiş için önemli belirleyiciler olarak bulundu. Konversiyon grubunda ameliyat süresi, oral alıma kadar geçen süre ve komplike apandisit insidansı anlamlı olarak daha yüksekti. Konversiyon grubunda ameliyat sonrası komplikasyon, cerrahi alan enfeksiyonu, hastaneye tekrar yatış ve ölüm oranları anlamlı derecede yüksekti. Açık cerrahiye dönüşüm ile ilişkili komplikasyon oranlarındaki artıştan kaçınmak için, ileriye dönük risk faktörleri olan bir hastanın ilk değerlendirilmesi faydalı olabilir.

Anahtar sözcükler: Apendektomi; açık cerrahiye dönüşüm; laparoskopik; komplikasyonlar; risk faktörleri.

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