Identification of preoperative risk factors associated with the conversion of laparoscopic to open appendectomies

Original Article

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ABSTRACT

Background: One of the most frequent surgical emergencies in the world is acute appendicitis. In recent years, laparoscopic appendectomy has been the treatment of choice for adult patients because of its widespread acceptability. This study sought to assess the preoperative risk factors for conversion as well as the results of adult patients who had laparoscopic to open appendectomy conversion.

Patients and Methods: This retrospective analysis involved 100 patients who underwent laparoscopic appendectomy and had a clinical diagnosis of acute appendicitis. Patients were all 18 years old and above. Patient demographics, comorbidities, preoperative laboratory results, computed tomography, and ultrasound findings, surgical time, intraoperative findings, need for conversion, duration of hospital stay, postoperative morbidity, and readmissions were all gathered for study.

Results: Of the participants in our study, 11% had converted from a laparoscopic to an open approach. According to univariate logistic regression analysis, there were several significant risk factors for conversion, including intra-abdominal fluid, appendicular perforation, appendicular necrosis or gangrene, perithyphilitic abscess, peritonitis, high white blood cell (WBCs) count, high BMI, patients with high American Society of Anesthesiologists score, diabetes mellitus, and high C-reactive protein (CRP). Only high WBC count, high CRP, appendicular perforation, appendicular necrosis or gangrene, perithyphilitic abscess, and peritonitis were identified to be significant risk variables of conversion on multivariate logistic regression analysis.

Conclusion: The laparoscopic method is an effective treatment for most patients with acute appendicitis. High preoperative WBC count and CRP levels, as well as radiographic abnormalities (perforation, necrosis or gangrene, perithyphilitic abscess, and peritonitis), were the preoperative independent risk factors for the requirement for conversion.

Key Words: Acute appendicitis, conversion, laparoscopic, open appendectomies, preoperative, risk factors.

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INTRODUCTION

With an annual incidence of □233 per 100 000 population, with a lifetime incidence risk ranging from 6.7 to 8.6%, acute appendicitis is one of the most prevalent surgical emergencies in the world[1]. In recent years, laparoscopic appendectomy (LA) has been the treatment of choice for adult patients after gaining widespread approval[2,3].

Shorter hospital stays, less need for postoperative analgesics, early food tolerance and return to regular activities, and less postoperative problems are the benefits of LA over open surgery[3,4]. Furthermore, rates of conversion to open surgery range from 1 to 10%, and its use for treating complex appendicitis is becoming more common[5]. Conversion to open surgery may still happen in LA despite growing expertise[6]. Intraoperative issues such as adhesions, retrocecal appendix, or severe appendicitis may impact the choice to convert[7]. Understanding the risk factors for conversion might enable surgeons to counsel patients more carefully about the likelihood of conversion and could also encourage the development of methods to lower that risk[8].

Consequently, preoperative variables linked to a higher chance of conversion may be useful in determining the best surgical strategy for individuals suffering from acute appendicitis[9]. Numerous criteria, such as age, sex, diabetes, American Society of Anesthesiologists (ASA) score, white blood cell (WBC), and C-reactive protein (CRP) levels, the outcomes of the preoperative computed tomography scan, and the intraoperative presence of complex appendicitis, have previously been identified in previous research[10].

This study sought to assess the preoperative risk factors for conversion as well as the results of adult patients who had laparoscopic to open appendectomy conversion.

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PATIENTS AND METHODS:

This retrospective research, where data was collected from records of the Suez Canal University hospitals', Department of Surgery from March 2022 to October 2023, comprised 100 adult patients (aged 18 and above[11]), who had been clinically diagnosed with acute appendicitis and had undergone laparoscopic procedures.

Patients with palpable appendicular masses, patients with suspected malignancies, and other acute abdomen diagnoses such as perforated viscus, ectopic pregnancy, pelvic inflammatory disease, and patients with incomplete or missing data or duplicate entries and loss to follow-up were all excluded.

The patient's demographic information (age, sex, and BMI), ASA score, comorbidities (diabetes, hypertension, symptoms), preoperative laboratory and radiological data, operative time (min), intraoperative details, drainage, and postoperative outcome parameters (length of hospital stay, postoperative complications, and readmission within 30 days postoperatively) were all gathered from the records.

The requirement for a midline laparotomy or a McBurney incision was characterized as conversion.

In every instance, abdominal ultrasonography and/or abdominal computed tomography (appendicular thickness >6 mm and periappendicular fat stranding) confirmed the clinical diagnosis of acute appendicitis[12]. Additionally, not all patients underwent computed tomography, as it was expensive, and once it was diagnosed by ultrasonography, there was no need for computed tomography. Regardless of the severity of the condition, all patients with an acute appendicitis diagnosis were hospitalized for surgery within 12 h of the diagnosis. The terms 'appendix perforation,' 'gangrene,' and 'abscess formation' describe complicated appendicitis. Peritonitis was characterized as purulent fluid localized in one or more quadrants.

Surgical technique and postoperative care

Using a three-port technique, a 10-mm port in the umbilical area, a 5-mm port in the suprapubic region, and a 5-mm port in the left iliac fossa, a LA was carried out under general anesthesia. In short, following an exploratory laparoscopy, the appendix was located, and the mesoappendix was cauterized with a bipolar device. Following the intracorporeal knotting of the appendiceal base, distal transection was carried out using scissors.

Depending on the surgeon's preference, either a midline laparotomy or a McBurney's incision was used during open surgery. In every instance of peritonitis, peritoneal lavage was carried out. Cases of perforated appendicitis or peritonitis needed abdominal drains. Antibiotic treatment was given to patients for 7 days following surgery if they had peritonitis, gangrenous, or perforated appendicitis, or both.

Outcomes

Finding important preoperative risk factors for laparoscopic to open appendectomy conversion was the main goal of the study. Secondarily, postoperative outcomes were analyzed comparing nonconversion group to the conversion group and to identify 30-day readmission, and mortality rates.

Statistical analysis

SPSS, v26 (IBM Inc., Armonk, New York, USA) for statistical analysis. Using the unpaired Student's t test, quantitative variables were compared between the two groups and provided as mean and SD. The frequency and percentage of the qualitative variables were reported, and when applicable, the Fisher's exact test or the χ^2 test was used for analysis. A statistically significant result was a two-tailed P value less than 0.05. The association between a dependent variable and one (univariate) or more (multivariate) independent variables may also be estimated using logistic regression.

RESULTS:

Regarding the baseline characteristics of the studied patients, we included 53 (53%) males and 47 (47%) females, their mean age was 45.2±9.19 years. The mean weight was 75.2±8.64 kg, the mean height was 1.6±0.08 m and the mean BMI was 30.1±3.98 kg/m^2. Of the studied patients, 54 (54%) patients were ASA I, 30 (30%) patients were ASA II, and 16 (16%) patients were ASA III. Among the studied patients, 20 (20%) patients were smokers. Regarding the associated comorbidities, 39 (39%) patients had hypertension, 22 (22%) patients had diabetes mellitus (DM), nine (9%) patients had hyperlipidemia, 11 (11%) patients had coronary artery disease (CAD), three (3%) patients had chronic obstructive pulmonary disease (COPD) and 12 (12%) patients had previous abdominal operations (Table 1).

Table 1: Baseline characteristics and comorbidities of the studied patients

	Total (*N*=100)
Age (years)	45.2±9.19
Sex	
Male	53 (53)
Female	47 (47)
Weight (kg)	75.2±8.64
Height (m)	1.6±0.08
BMI (kg/m^2)	30.1±3.98
ASA	
I	54 (54)
II	30 (30)
III	16 (16)
Smoking	20 (20)

Comorbidities	
HTN	39 (39)
DM	22 (22)
Hyperlipidemia	9 (9)
CAD	11 (11)
COPD	3 (3)
Previous abdominal operations	12 (12)

Data presented as mean±SD or frequency (%).
ASA, American Society of Anesthesiologists; CAD, coronary artery disease; COPD, chronic obstructive pulmonary disease; DM, diabetes mellitus; HTN, hypertension.

Table 2 shows the preoperative laboratory investigations, the mean WBCs was 9.5±1.45×10^9/l, and the mean CRP level was 63.4±28.59 mg/dl. The preoperative radiological diagnosis (where pelviabdominal ultrasound was the standard radiological tool), revealed that the mean appendiceal diameter was 8.7±1.93 mm, 23 (23%) patients had intra-abdominal fluid, and 14 (14%) patients had appendicolith.

Table 2: Preoperative laboratory investigations and radiological diagnosis of the studied patients

	Total (*N*=100)
Laboratory investigations	
WBCs (×10^9/l)	9.5±1.45
CRP (mg/dl)	63.4±28.59
Radiological diagnosis	
Appendiceal diameter (mm)	8.7±1.93
Intra-abdominal fluid	23 (23)
Appendicolith	14 (14)

Data presented as mean±SD or frequency (%).
CRP, C-reactive protein; WBCs, white blood cells.

Table 3 showed that the mean duration of surgery was 61.7±37.57 min. The peritoneal lavage was performed in 28 (28%) patients, and 24 (24%) patients required abdominal drainage. Regarding the intraoperative findings, perforation was found in 21 (21%) patients, necrosis or gangrene was found in eight (8%) patients, perithyphilitic abscess in 11 (11%) of patients, localized abscess was found in 20 (20%) patients, generalized peritonitis was found in nine (9%) patients, fecal peritonitis in one (1%) patient.

Table 3: Intraoperative data and findings

	Total (*N*=100)
Intraoperative data	
Duration of surgery (min)	61.7±37.57
Peritoneal lavage	28 (28)
Drainage	24 (24)
Intraoperative findings	
Perforation	21 (21)
Necrosis or gangrene	8 (8)
Perithyphilitic abscess	11 (11)
Localized abscess	20 (20)
Generalized peritonitis	9 (9)
Fecal peritonitis	1 (1)

Data presented as mean±SD or frequency (%).

Table 4 shows that the incidence of conversion was 11% of our studied patients. The reason for conversion was appendix base perforation in three (27.27%) patients, appendix base not recognized in two (18.18%) patients, severe adhesions in three (27.27%) patient, appendicular phlegmon in two (18.18%) patients, bleeding in one (9.09%) patient.

Table 4: Incidence and reason of conversion and of the studied patients

	Total (*N*=100)
Incidence of conversion	
Yes	11 (11)
No	89 (89)
Reason for conversion	
Appendix base perforation	3 (27.27)
Appendix base not recognized	2 (18.18)
Severe adhesions	3 (27.27)
Appendicular phlegmon	2 (18.18)
Bleeding	1 (9.09)

Data presented as frequency (%).

Regarding the outcome of the studied patients, the mean length of hospital stay was 1.8±0.9 days, wound infection occurred in two (2%) patients, intra-abdominal abscess occurred in one (1%) patient, bleeding occurred in one (1%) patient, cardiopulmonary complications occurred in one (1%) patient and readmissions within 30 days occurred in four (4%) patients. Sepsis, pneumonia, and mortality were not reported in our study (Table 5).

Table 5: Outcome of the studied patients

	Total (*N*=100)
Length of hospital stay (days)	1.8±0.9
Wound infection	2 (2)
Intra-abdominal abscess	1 (1)
Bleeding	1 (1)
Cardiopulmonary complications	1 (1)
Sepsis	0
Pneumonia	0
Readmissions within 30 days	4 (4)
Mortality	0

Data presented as frequency (%).

When comparing between patients with no conversion with those with conversion, age, weight, and BMI and were significantly higher in patients with conversion compared to those with no conversion (*P<0.001*). ASA was significantly different between both groups, with a high prevalence of ASA III in patients with conversion. HTN, DM, and previous abdominal operations were more prevalent in patients with conversion compared to those with no conversion (*P<0.05*). Three were insignificant differences between both groups regarding sex, height, smoking, hyperlipidemia, CAD, and COPD (Table 6).

Table 6: Baseline characteristics of the studied groups regarding the incidence of conversion

	No conversion (*N*=89)	Conversion (*N*=11)	*P* value
Age (years)	25.8±5.66	43±10.74	<0.001*
Sex			
Male	47 (52.81)	6 (54.55)	0.913
Female	42 (47.19)	5 (45.45)	
Weight (kg)	61.3±6.78	78.0±7.9	<0.001*
Height (m)	1.62±0.08	1.64±0.07	0.537
BMI (kg/m^2)	26.5±3.49	34.3±4.04	<0.001*
ASA			
I	52 (58.43)	2 (18.18)	<0.001*
II	27 (30.34)	3 (27.27)	
III	10 (11.24)	6 (54.55)	
Smoking	17 (19.1)	3 (27.27)	0.688
Comorbidities			
HTN	31 (34.83)	8 (72.73)	0.023*
DM	17 (19.1)	5 (45.45)	0.046*
Hyperlipidemia	7 (7.87)	2 (18.18)	0.259
CAD	9 (10.11)	2 (18.18)	0.419
COPD	3 (3.37)	0	0.513
Previous abdominal operations	8 (8.99)	4 (36.36)	0.025*

Data presented as mean±SD or frequency (%).
ASA, American Society of Anesthesiologists; CAD, coronary artery disease; COPD, chronic obstructive pulmonary disease; DM, diabetes mellitus; HTN, hypertension.
*Statistically significant as *P value* less than 0.05.

Table 7 shows that WBCs and CRP were significantly elevated in patients with conversion compared to those with no conversion (*P<0.001* and *0.001*). Regarding the preoperative radiological diagnosis, number of patients with intra-abdominal fluid was significantly higher in patients with conversion compared to those with no conversion (*P=0.002*), while appendiceal diameter and appendicolith were comparable between both groups.

Table 7: Preoperative laboratory investigations and radiological diagnosis of the studied groups regarding the incidence of conversion

	No conversion (*N*=89)	Conversion (*N*=11)	*P* value
Laboratory investigations			
WBCs (×10^9/l)	9.2±1.14	12.1±0.94	<0.001*
CRP (mg/dl)	54.98±12.89	131.7±29.34	<0.001*
Radiological diagnosis			
Appendiceal diameter (mm)	8.8±1.92	7.6±1.8	0.055
Intra-abdominal fluid	16 (17.98)	7 (63.64)	0.002*
Appendicolith	12 (13.48)	2 (18.18)	0.650

Data presented as mean±SD.
CRP, C-reactive protein; WBCs, white blood cells.
*Statistically significant as *P value* less than 0.05.

Regarding the intraoperative data, duration of surgery, peritoneal lavage, and drainage were significantly higher in patients with conversion compared to those without conversion (*P<0.05*). All the intraoperative findings (perforation, necrosis or gangrene, perithyphilitic abscess localized and generalized peritonitis and fecal peritonitis) were significantly higher in patients with conversion compared to those with no conversion (*P<0.05*) (Table 8).

Table 8: Intraoperative findings of the studied groups regarding the incidence of conversion

	No conversion (*N*=89)	Conversion (*N*=11)	*P* value
Intraoperative data			
Duration of surgery (min)	54.8±29.56	118.1±48.51	<0.001*
Peritoneal lavage	22 (24.72)	6 (54.55)	0.038*
Drainage	18 (20.22)	6 (54.55)	0.012*
Intraoperative findings			
Perforation	16 (17.98)	5 (45.45)	0.034*
Necrosis or gangrene	5 (5.62)	3 (27.27)	0.041*
Perithyphilitic abscess	6 (6.74)	5 (45.45)	<0.001*
Localized peritonitis	17 (19.1)	3 (27.27)	<0.001*
Generalized peritonitis	5 (5.62)	4 (36.36)	0.008*
Fecal peritonitis	0	1 (9.09)	<0.001*

Data presented as mean±SD.
CRP, C-reactive protein; WBCs, white blood cells.
*Statistically significant as *P value* less than 0.05.

Regarding the intraoperative data, duration of surgery, peritoneal lavage, and drainage were significantly higher in patients with conversion compared to those without conversion (*P<0.05*). All the intraoperative findings (perforation, necrosis or gangrene, perithyphilitic abscess localized and generalized peritonitis and fecal peritonitis) were significantly higher in patients with conversion compared to those with no conversion (*P<0.05*) (Table 8).

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Intraoperative data			
Duration of surgery (min)	54.8±29.56	118.1±48.51	<0.001*
Peritoneal lavage	22 (24.72)	6 (54.55)	0.038*
Drainage	18 (20.22)	6 (54.55)	0.012*
Intraoperative findings			
Perforation	16 (17.98)	5 (45.45)	0.034*
Necrosis or gangrene	5 (5.62)	3 (27.27)	0.041*
Perithyphilitic abscess	6 (6.74)	5 (45.45)	<0.001*
Localized peritonitis	17 (19.1)	3 (27.27)	<0.001*
Generalized peritonitis	5 (5.62)	4 (36.36)	0.008*
Fecal peritonitis	0	1 (9.09)	<0.001*

Data presented as frequency (%).
*Statistically significant as *P value* less than 0.05.

Concerning the outcomes, the length of hospital stay was significantly prolonged in patients with conversion compared to those without conversion (*P<0.001*). Other outcomes (wound infection, intra-abdominal abscess, bleeding, cardiopulmonary complication, and readmissions within 30 days) were insignificantly different between both groups (Table 9).

Table 9: Outcomes of the studied groups regarding the incidence of conversion

	No conversion (*N*=89)	Conversion (*N*=11)	*P* value
Length of hospital stay (days)	1.5±0.5	4.0±1.26	<0.001*
Wound infection	0	2 (18.18)	1.000
Intra-abdominal abscess	0	1 (9.09)	0.110
Bleeding	0	1 (9.09)	0.110
Cardiopulmonary complication	0	1 (9.09)	0.110
Sepsis	0	0	–
Pneumonia	0	0	–
Readmissions within 30 days	2 (2.25)	2 (18.18)	0.059
Mortality	0	0	–

Data presented as frequency (%).
*Statistically significant as *P value* less than 0.05.

On univariate logistic regression analysis, age, BMI, ASA, DM, WBCs, CRP, intra-abdominal fluid, perforation, necrosis, or gangrene, perithyphilitic abscess, and peritonitis were significant risk factors of conversion. On multivariate logistic regression analysis, we found that only WBCs, CRP, perforation, necrosis, or gangrene, perithyphilitic abscess, and peritonitis were significant risk factors of conversion (Table 10).

Table 10: Logistic regression analysis of risk factors of conversion

	Univariate			Multivariate		
Variables	*P* value	OR	95% CI	*P* value	OR	95% CI
Old age (years)	0.028*	2.818	1.1186 to 7.0972	0.145	1.022	0.9923 to 1.053
Sex	0.913	0.933	0.2651 to 3.2800	0.530	0.259	0.003 to 17.506
High BMI (kg/m^2)	0.001*	1.528	1.2033 to 1.9406	0.052	1.316	0.9974 to 1.736
ASA	0.002*	4.116	1.691 to 10.015	0.652	1.421	0.3072 to 6.581
HTN	0.095	0.306	0.0762 to 1.2304	0.297	0.3169	0.0366 to 2.745
DM	0.031*	0.236	0.0636 to 0.8746	0.112	0.251	0.0455 to 1.383
Hyperlipidemia	0.274	0.384	0.0691 to 2.1359	0.551	2.376	0.138 to 40.899
CAD	0.427	0.506	0.0943 to 2.7164	0.657	1.8770	0.116 to 30.224
COPD	0.059	0.228	0.0490 to 1.0566	0.204	0.094	0.0025 to 3.599
Previous abdominal operations	0.084	0.263	0.0580 to 1.1955	0.420	0.3148	0.0186 to 5.321
WBCs (×10^9/l)	0.012*	39.806	2.288 to 692.462	0.029*	28.29	1.867 to 428.65
CRP (mg/dl)	<0.001*	1.070	1.0365 to 1.1044	<0.001*	1.0747	1.035 to 1.115
Appendiceal diameter (mm)	0.064	0.701	0.4813 to 1.0202	0.186	0.770	0.5240 to 1.134
Intra-abdominal fluid	0.002*	0.125	0.0327 to 0.4794	0.088	0.065	0.0029 to 1.507
Appendicolith	0.673	0.701	0.1349 to 3.6463	0.053	7.558	0.974 to 58.607
Duration of surgery (min)	0.170	1.011	0.9954 to 1.0264	0.385	1.007	0.9905 to 1.025
Perforation	0.045*	0.263	0.0714 to 0.9693	<0.001*	0.008	0.001 to 0.083
Necrosis or gangrene	0.025*	0.159	0.0319 to 0.7898	<0.001*	0.014	0.0024 to 0.085
Perithyphilitic abscess	0.004*	0.104	0.0227 to 0.4783	<0.001*	0.006	0.001 to 0.0649
Peritonitis	0.004*	0.143	0.0379 to 0.5361	0.038*	0.154	0.0264 to 0.907

ASA, American Society of Anesthesiologists; CAD, coronary artery disease; CI, confidence interval; COPD, chronic obstructive pulmonary disease; CRP, C-reactive protein; DM, diabetes mellitus; HTN, hypertension; OR, odds ratio; WBCs, white blood cells.
*Statistically significant as *P value* less than 0.05.

On univariate logistic regression analysis, old age, high BMI, ASA, WBCs, CRP, intra-abdominal fluid, perforation, necrosis, or gangrene, perithyphilitic abscess, peritonitis and conversion were significant risk factors of morbidity. On multivariate logistic regression analysis, we found that only age, WBCs, CRP, and conversion were significant risk factors for morbidity (Table 11).

Table 11: Logistic regression analysis of risk factors of morbidity

	Univariate			Multivariate		
Variables	*P* value	OR	95% CI	*P* value	OR	95% CI
Old age (years)	0.014*	1.0654	1.0126 to 1.1209	0.033*	1.0582	1.0046 to 1.114
Sex	0.222	1.653	0.7376 to 3.7070	0.198	2.3047	0.6452 to 8.232
BMI (kg/m^2)	0.033*	1.1068	1.0082 to 1.2151	0.077	1.0858	0.990 to 1.1898
ASA	<0.001*	28.949	8.8003 to 95.229	0.800	0.9326	0.543 to 1.6004
HTN	0.192	1.7143	0.7620 to 3.8567	0.139	1.9149	0.808 to 4.5375
DM	0.728	0.8606	0.3688 to 2.0083	0.427	0.6923	0.279 to 1.7177
Hyperlipidemia	0.267	2.509	0.4937 to 12.754	0.565	0.4837	0.0407 to 5.747
CAD	0.055	7.8000	0.9572 to 63.561	0.057	7.670	0.937 to 62.739
COPD	0.054	0.2481	0.0600 to 1.0253	0.057	0.2466	0.0582 to 1.045
Previous abdominal operations	0.055	7.800	0.9572 to 63.561	0.0659	7.7681	0.873 to 69.047
WBCs (×10^9/l)	0.011*	1.470	1.0941 to 1.9760	0.007*	1.5256	1.1227 to 2.073
CRP (mg/dl)	0.005*	1.0241	1.0074 to 1.0411	0.023*	1.0206	1.002 to 1.0386
Appendiceal diameter (mm)	0.865	0.982	0.7974 to 1.2096	0.627	0.9469	0.759 to 1.1800
Intra-abdominal fluid	0.048*	3.0000	1.0110 to 8.9018	0.315	1.5469	0.6598 to 3.626
Appendicolith	0.132	5.150	0.608 to 43.594	0.165	5.2155	0.504 to 53.919
Duration of surgery (min)	0.797	1.0016	0.9896 to 1.0137	0.587	1.0035	0.990 to 1.0163
Perforation	0.014*	0.2593	0.0879 to 0.7643	0.502	0.5534	0.0983 to 3.114
Necrosis or gangrene	<0.001*	0.1230	0.0406 to 0.3731	0.892	0.9434	0.4065 to 2.189
Perithyphilitic abscess	0.015*	0.2397	0.0760 to 0.7561	0.856	0.8399	0.1263 to 5.586
Peritonitis	0.026*	0.3082	0.1091 to 0.8706	0.592	0.7111	0.204 to 2.4734
Conversion	0.009*	8.4194	1.7117 to 41.412	0.002*	12.5762	2.503 to 63.185

ASA, American Society of Anesthesiologists; CAD, coronary artery disease; CI, confidence interval; COPD, chronic obstructive pulmonary disease; CRP, C-reactive protein; DM, diabetes mellitus; HTN, hypertension; OR, odds ratio; WBCs, white blood cells.
*Statistically significant as P value less than 0.05.

DISCUSSION

Currently, the laparoscopic approach is thought to be the accepted procedure for doing an appendectomy for acute appendicitis. However, conversion to an open surgery may be required for certain individuals[13]. The knowledge of risk factors regarding the need for conversion, especially preoperative ones, could help with the decision of utilizing primarily an open approach for selected patients with a high conversion risk. This can help prevent unnecessary costs, extended operating times, and an increased risk of morbidity[14].

In our study, 11% of the population were converted from laparoscopic to open approach. The literature reports varying conversion rates in LA, ranging from 1 to 27%[5,15]. Conversion to open surgery was required in 67 (5.4%) instances of the 1220 patients who underwent LA in Bancke Laverde *et al*.[16] retrospective research. This is in line with previously reported conversion rates[17,18].

A different study by Finnerty and colleagues discovered that the conversion rate had remained steady at about 5%. Surgeons may be able to choose an open appendectomy approach primarily by identifying patients who are most likely to convert, thus saving time, money, and morbidity during surgery. Although the decision to convert from laparoscopic to open appendectomy in the operating room can be subjective and dependent on individual surgeon skills, identifying objective preoperative parameters associated with conversion can provide a lower threshold for proceeding with the potentially inevitable open approach, mitigating costs and morbidity[19].

A 7.9% conversion rate was found in an analysis of the 151.774 patients in the nationwide inpatient sample[15]. Similarly, another study including 705 patients undergoing LA showed a conversion rate of 9.7%[20]. Ninety-eight percent of the patients in the Monrabal Lezama *et al*.[6] research had effective laparoscopic treatment (a 2% conversion rate), which may be attributed to their institution's extensive training in laparoscopic surgery. Furthermore, over time, conversion rates have dramatically dropped. A 12-year trend analysis of the Swiss Association of Laparoscopic and Thoracoscopic Surgery, which was population based, revealed a 1.58% conversion rate with a decline in conversion rates over time[21].

We found that age, BMI, ASA, DM, WBCs, CRP, intra-abdominal fluid, perforation, necrosis, or gangrene, perithyphilitic abscess, and peritonitis were significant risk variables of conversion on univariate logistic regression analysis. Only WBCs, CRP, perforation, necrosis, or gangrene, perithyphilitic abscess, and peritonitis were revealed to be significant risk variables of conversion on multivariate logistic regression analysis. Age, BMI, ASA, WBCs, CRP, intra-abdominal fluid, perforation, necrosis, or gangrene, perithyphilitic abscess, peritonitis, and conversion were found to be significant risk variables of morbidity on univariate logistic regression analysis. The only variables determined to be significant risk factors of morbidity on multivariate logistic regression analysis were age, WBCs, CRP, and conversion.

In the study made by Jaschinski *et al*.[22], severe inflammatory adhesions that obscure the anatomy or cause friability or perforation are the most frequent causes of conversion from laparoscopic to open appendectomy. Male sex, advanced age, ASA score more than 2, leukocytosis, lack of familiarity with laparoscopic procedures, high grades of appendiceal inflammation or rupture on computed tomography scan, and diffuse peritonitis are preoperative factors that have been linked to conversion in the study made by Agrawal *et al*.[23]. However, any significant powered study to identify a full list of conversion variables is precluded by the very small number of conversions in single-institution cohorts. Moreover, the differences in postoperative results between conversion from laparoscopic to open appendectomy (CA) and laparoscopic-only appendectomy (LA) are yet unknown[24].

Furthermore, age 40, male sex, black race, diabetes, obesity, and a preoperative diagnosis of severe appendicitis were found to be independent risk factors for conversion on multivariable analysis by Finnerty *et al*.[19]. Several patient factors, including male sex, older age, ASA class more than 2, leukocytosis, lack of competence with laparoscopic procedures, inflammation or free air on computed tomography scan, and diffuse peritonitis, have been linked to conversion in previous studies[25–27].

A higher preoperative WBC count, a higher preoperative CRP value, the presence of an intraoperative perforation, an intraoperative necrosis or gangrene, an intraoperative perityphlitic abscess, or an intraoperative peritonitis were the six independent risk factors for conversion that Bancke Laverde *et al*.[16] identified in their study. Past research supports the identification of five of the six risk variables outlined above[5,19].

Aydin *et al*.[28] and Yigit *et al*.[10] have previously shown that patients requiring conversion had a significantly higher preoperative CRP level than patients undergoing complete LA; however, the ideal threshold for a high CRP level varies slightly between the studies (≥108.5 mg/dl and ≥119 mg/dl). The degree of appendicitis may be expressed by the preoperative CRP level, which might be critical in determining whether to convert. Accordingly, the intraoperative signs of advanced appendicitis are again the decisive risk factors for the need for conversion. The evidence from Bancke Laverde *et al*.[16] supports this, as patients who have perithyphilitic abscess, peritonitis, necrosis or gangrene, or perforation are more than twice as likely to convert. These intraoperative parameters have also been reported in the literature[27,29].

It has not been explained how a greater preoperative WBC count and an elevated conversion rate, which was observed, are related[28]. This link seems probable since, like an elevated CRP, an elevated WBC count may also indicate more advanced appendicitis. Other previously found risk variables linked to a greater probability of conversion were age, diabetes, and ASA III–IV. These characteristics did not become statistically significant in the multivariate analysis while being linked in the univariate analysis of the Bancke Laverde *et al*.[16] cohort to an increased chance of a conversion. The male sex is another stated risk indicator for conversion that may be verified as univariate or multivariate[30].

Using univariable analysis, several risk variables for conversion were found in the Srivastav *et al*.[31] research. ASA score more than two points, male sex, advanced age, increased leukocyte count, and radiologically shown inflammatory severity (e.g., periappendicular adhesions, ruptured appendix with peritonitis, gangrenous appendix) are some of these. Multivariable analysis incorporating these factors available to the surgeon preoperatively identified advanced age, ASA score more than two points, and

severity of adhesions are significantly associated with conversion. These results highlight the complex nature of the decision to convert, as much as baseline patient characteristics, disease severity, and surgeon factors, as each independently impacts the probability of a successful laparoscopic procedure. To safely separate patients into two groups – one for LAs with little risk of conversion to OA and the other with a significant conversion rate – a thorough evaluation of the patient's risk factors, blood tests, and positive ultrasonography findings of appendicitis are necessary.

In terms of postoperative results, we discovered that the average duration of hospital stay was 1.8±0.9 days; two (2%) patients experienced wound infection; one (1%) patient experienced intra-abdominal abscess; one (1%) patient experienced bleeding; one (1%) patient experienced cardiopulmonary complications; and four (4%) patients experienced readmissions within 30 days. In our study, sepsis, pneumonia, and death were not documented. Patients who underwent conversion had a considerably longer hospital stay than those who did not ($P<0.001$). The other outcomes that were not substantially different between the two groups were hemorrhage, intra-abdominal abscess, wound infection, cardiopulmonary problems, and readmissions within 30 days.

According to Hellberg *et al*.[32] the converted group required a much longer amount of time to recover completely, a longer hospital stay, and an extended amount of time for surgery and anesthesia. When a laparoscopic procedure is converted to an open one, more incisions must be performed, which increases the risk of surgical trauma. Another possible explanation might be that the patients in the converted group had more noticeable inflammation. The longer operating time and anesthetic time in these patients could also be of importance.

Although other studies have reported lower percentages, which may indicate stronger skills or a different mix of patients, the 11% conversion rate is well in line with previously published data[33–35]. The complication rate in the converted group was not significantly higher, which might have been expected because complications are largely related to the degree of inflammation rather than the operative technique[36].

Comparing conversion to open and laparoscopic procedures, Finnerty *et al*.[19] found a greater rate of wound infection. Furthermore, the research confirms a greater incidence of readmissions and resurgeries as well as a longer length of stay following surgery in patients who need conversion[10,19,27,30].

According to Shimoda *et al*.[9], switching to open surgery meant a lengthier hospital stay, a longer operating time, and a delayed oral intake.

The strength of our study is that our data suggest that patients requiring conversion may benefit from special attention in the postoperative course and from a more customized therapy, as they are exposed to an increased postoperative risk.

There are a number of restrictions on our data: First, there may be bias due to the single-center design and retrospective aspect of this investigation. Second, the sample size is rather small. Larger cohort studies are required to confirm our findings.

CONCLUSION

The laparoscopic method is an effective treatment for most patients with acute appendicitis. High preoperative WBC count and CRP levels, as well as radiographic abnormalities (perforation, necrosis or gangrene, perithyphilitic abscess, and peritonitis), were the preoperative independent risk factors for the requirement for conversion. The choice to convert is based on intraoperative findings and preoperative risk factors. However, there is a higher chance of surgical problems if conversion is required, thus the affected patients' postoperative care should be more closely monitored.

CONFLICT OF INTEREST

There are no conflicts of interest.

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