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ORIGINAL SCIENTIFIC REPORT

# Risk Factors for Readmission After Short-Hospital-Stay Laparoscopic Appendectomy

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## Abstract

*Background* Single-day discharge is a common practice among patients undergoing laparoscopic appendectomy (LA). We aimed to determine risk factors associated with readmission in patients with short hospital stay after LA.

*Methods* We performed a retrospective analysis of all patients who underwent LA during the period 2006–2019. Patients with length of hospital stay shorter than 24 h were included. Demographics, operative variables, and postoperative outcomes were analyzed. Multivariable logistic regression was performed to determine risk factors for readmission.

*Results* A total of 2009 LA were performed during the study period; 1506 (75%) patients had short hospital stay and were included in the analysis. Median age was 31 (14–85) years, and 720 (48%) were female. Mild peritonitis was diagnosed in 423 (28%) patients, and 121 (8%) had gangrenous/perforated appendicitis. Mean surgical time was 51(14–180) min. Conversion rate was 0.4%. There were 143 (9%) postoperative complications, including 29 (1.9%) patients with postoperative intra-abdominal abscess. Nine patients (0.6%) underwent reoperation, and only 26 (1.7%) patients were readmitted. The mean time to hospital readmission was 6 (1–14) days. Although age >50 years, obesity, mild peritonitis, and complicated appendicitis were more frequent among patients readmitted, only age >50 years (OR 3.54 95% CI 1.51–8.30) and mild peritonitis (OR 6.16 95% CI 1.80–34.93) were found as independent risk factors for readmission.

*Conclusion* Most patients undergoing LA can be safely discharged within 24 h of admission. Patients over 50 years old and/or with localized peritonitis have significantly higher risk of readmission and therefore may need a closer postoperative follow-up.

## Introduction

Acute appendicitis is the most common indication for emergency surgery, with an estimated incidence of 100 per 100,000 persons-year in the USA [1]. Despite that medical treatment with antibiotics alone has been proposed as curative treatment, laparoscopic appendicectomy (LA) still represents the gold standard treatment [2].

Currently, length of hospital stay (LOS) after gastrointestinal surgery tends to decrease due to the use of minimally invasive techniques and enhanced recovery protocols after surgery [3]. Moreover, as LA is commonly performed in young and healthy individuals and has low postoperative morbidity [4], several reports have shown the safety and feasibility of short hospital stay (<24 h) or ambulatory (same working-day) LA [3–9]. A short hospital stay after LA has the potential of reducing healthcare expenses without jeopardizing patient's postoperative outcomes [5].

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Shorter LOS may also result in a rising number of patients suffering from complications after hospital discharge and readmissions. However, scarce evidence is available regarding risk factors for hospital readmission after short-stay LA. Therefore, the aim of this study was to identify perioperative variables associated with unexpected readmissions after short-stay LA.

## Materials and methods

### Study design and population

We performed a retrospective analysis of a prospectively collected database of all patients who underwent laparoscopic appendectomy for acute appendicitis (AA) during the period 2006–2019. All patients diagnosed with acute appendicitis who underwent LA and were discharged within 24 h of admission were included for analysis. Exclusion criteria were the following: <16 years old, conventional approach, and patients with LOS longer than 24 h.

Diagnosis of acute appendicitis was based on clinical, laboratory, and imaging findings (appendicular thickening >7 mm and periappendicular fat stranding on abdominal ultrasound or computed tomography). Once diagnosed, patients were admitted for surgery within 12 h of the diagnosis. Complicated appendicitis was defined as perforation of the appendix, gangrene, empyema, or abscess formation. The presence, extension, and characteristics of the peritoneal fluid were recorded in the operative note by the surgeon. The severity of peritonitis was then classified as mild (turbid/purulent fluid localized in one quadrant) or severe (fecal peritonitis or turbid/purulent fluid in more than one quadrant). Short LOS after LA was defined as hospital discharge within 24 h of admission.

Upon induction of general anesthesia, a single intravenous dose of amoxicillin plus clavulanic acid (2 g) was administered. A laparoscopic three-port technique was used as previously described [10]. Briefly, after an exploratory laparoscopy, the appendix was identified, and a bipolar plier was used to coagulate the mesoappendix. After the appendiceal base was tied with an endo-loop, distal transection with scissors was performed. The appendix was always removed through the suprapubic port. Peritoneal lavage was performed in all cases of peritonitis. No nasogastric tube or urinary catheter was placed. Abdominal drains were used according to surgeons' criteria.

Patients with gangrenous or perforated appendicitis and/or with peritonitis underwent antibiotic therapy for 7 days postoperatively. Opioid-sparing multimodal analgesia was administered postoperatively. Ambulation and oral feeding with clear liquids was resumed when patients were fully awaked. Short hospital stay (<24 h) was considered for all patients who underwent an uneventful LA without severe peritonitis and who fulfilled the following criteria: normal vital signs, adequate oral intake, satisfactory pain control, ability to ambulate and urinate, and appropriate supervision/assistance at home.

Follow-up was scheduled at clinics on postoperative days 7 and 30. Routine laboratory and imaging studies were not performed unless a postoperative complication was clinically suspected. Postoperative intra-abdominal abscesses (IAA) were treated with intravenous antibiotics alone, percutaneous drainage or laparoscopic lavage according to our institution treatment algorithm [11]. Timing for readmission was recorded as the number of days from the moment of hospital discharge.

The institutional review board (IRB) approved this study. The written informed consent was waived by the IRB owing to the study's retrospective nature.

### Variables and outcomes

Data collected included age, gender, body mass index (BMI), and American Society of Anesthesiologists (ASA) classification. Operative variables such as grade of appendicitis (normal, catarrhal, phlegmonous, gangrenous or perforate), severity of peritonitis, conversion rate, operative time, and intraoperative complications were also registered. Morbidity following Clavien–Dindo classification, mortality, and readmissions were also assessed.

### Statistical analyses

The student's $t$ test was used to compare continuous variables, whereas the $\chi^2$ test was used for categorical variables. Multivariate logistic regression analysis was used to determine risk factors for readmission. A $p$ value $< 0.05$ was considered statistically significant for all tests.

## Results

During the study period, a total of 2015 appendectomies were performed; 2009 (99.7%) were performed laparoscopically, and 1506 (75%) met the inclusion criteria being discharged within 24 h of admission.

Median age was 31 (14–85) years and 720 (48%) were female; 216 (14%) patients were older than 50 years. Most patients (99%) had low anesthesiologic risk (ASA score I–II). Clinical diagnosis of appendicitis was supported by ultrasound in 1274 (85%) patients and by computed tomography in 232 (15%) patients (Table 1).

**Table 1** Preoperative and intraoperative variables

| | Patients with short hospital stay *n* 1506 |
|---|---|
| Sex | |
| Female, *n* (%) | 720 (48) |
| Male, *n* (%) | 786 (52) |
| Median age *(range)* years | 31 (14–85) |
| ASA, *n* (%) | |
| I | 1188 (79) |
| II | 304 (20) |
| III | 14 (1) |
| IV | 0 (0) |
| Comorbidities, *n* (%) | |
| Hypertension | 72 (5) |
| Coronary heart disease | 11 (0.73) |
| BMI >30 kg/m$^2$ | 66 (4.38) |
| Diabetes | 15 (1) |
| Smoking | 60 (4) |
| Chronic obstructive pulmonary disease | 10 (0.66) |
| Diagnostic imaging, *n* (%) | |
| Ultrasound | 1274 (85) |
| CT | 232 (15) |
| Mean WBC, *(range)*/mm$^3$ | 13,113 (6420–23,000) |
| Grading of acute appendicitis, *n* (%) | |
| Normal | 87 (6) |
| Catarrhal | 131 (9) |
| Phlegmonous | 1167 (77) |
| Gangrenous | 113 (8) |
| Perforated | 8 (0.5) |
| Operative time, (range) minutes | 51 (15–180) |
| Conversion rate, *n* (%) | 6 (0.4) |
| Intraoperative complications, *n* (%) | 10 (0.6) |
| | 7-port-site bleeding |
| | 3 bowel injury |
| Mild peritonitis, *n* (%) | 423 (28) |

*CT* computed tomography, *BMI* body mass index, *WBC* white blood cells

**Table 2** Postoperative outcomes

| | Patients with short hospital stay *n* 1506 |
|---|---|
| Unexpected consults, *n* (%) | 119 (7.9) |
| Readmissions, *n* (%) | 26 (1.7) |
| | 18 intra-abdominal abscesses |
| | 3 hemoperitoneum |
| | 1 appendicitis of the stump |
| | 1 deep vein thrombosis |
| | 1 wound infection |
| | 1 fever and abdominal pain |
| | 1 ileus |
| Clavien–Dindo | |
| I, *n* (%) | 105 (7) |
| | 36 wound infection |
| | 27 fever |
| | 17 abdominal pain |
| | 13 ileus |
| | 8 hematoma and wound dehiscence |
| | 2 phlebitis |
| | 2 cutaneous rash |
| II, *n* (%) | 21 (1) |
| | 16 intra-abdominal abscesses |
| | 2 wound infection |
| | 1 phlebitis |
| | 1 deep vein thrombosis |
| | 1 cutaneous rash |
| IIIa, *n* (%) | 7 (0.5) |
| | 7 intra-abdominal abscesses |
| IIIb, *n* (%) | 9 (0.6) |
| | 5 intra-abdominal abscesses |
| | 3 hemoperitoneum |
| | 1 appendicitis of the stump |
| IV, *n* (%) | 1 (0.07) |
| | 1 septic shock |
| Overall morbidity | 143 (9) |
| Mortality, *n* (%) | 0 (0) |

Mean operative time was 51 (14–180) min. Conversion and intraoperative complication rates were 0.4% and 0.6%, respectively. Gangrenous or perforated appendicitis was found in 121 (8%) patients and mild peritonitis in 423 (28%) cases. Abdominal drain was placed in 10 (0.7%) patients.

Overall postoperative morbidity was 9% (143 patients). Twenty-nine patients (1.9%) developed postoperative IAA, from which 16 (55%) were treated with antibiotics only, 7 (24%) with percutaneous drainage, and 6 (21%) with laparoscopic lavage and drainage. There was no mortality in the series (Table 2). There were 119 (7.9%) postoperative consults to the emergency, department and 26 (1.7%) patients were readmitted. The mean time to hospital readmission was 6 (1–14) days. The indications for readmission were: 18 (69%) intra-abdominal abscess, 3 (11%) hemoperitoneum, 1 (4%) stump appendicitis, 1 (4%) deep vein thrombosis, 1 (4%) wound infection, 1 (4%) fever, and 1 (4%) ileus.

Age ≥50 years (38% vs. 14%, $p = 0.001$), BMI >30 kg/m$^2$ (15% vs. 4%, $p = 0.01$), gangrenous/perforated appendicitis (19% vs. 8%, $p = 0.04$), and mild peritonitis

**Table 3** Characteristics of patients with and without readmission

| Variable | Non-readmitted patients *n* 1480 (%) | Readmitted patients *n* 26 (%) | *p* |
|---|---|---|---|
| Female sex | 709 (48) | 11 (42) | 0.68 |
| Age, ≥50 years | 206 (14) | 10 (38) | **0.001** |
| BMI, >30 kg/m$^2$ | 62 (4) | 4 (15) | **0.01** |
| Hypertension | 71 (5) | 1 (4) | 0.81 |
| Coronary heart disease | 12 (0.81) | 0 (0) | 0.51 |
| Diabetes | 15 (1) | 0 (0) | 0.63 |
| Smoking | 57 (4) | 3 (12) | 0.11 |
| Chronic obstructive pulmonary disease | 9 (0.61) | 1 (4) | 0.43 |
| Conversion to open surgery | 6 (0.41) | 0 (0) | 0.99 |
| Drainage | 10 (0.68) | 0 (0) | 0.99 |
| WBC, >*19*/mm$^3$ | 113 (7.64) | 4 (15) | 0.16 |
| Operative time, >*90* min | 121 (8) | 2 (8) | 0.57 |
| Mild peritonitis | 411 (28) | 12 (46) | **0.01** |
| Gangrenous/perforated appendicitis | 116 (8) | 5 (19) | **0.04** |

$p < 0.05$ are denoted in bold

*BMI* body mass index, *WBC* white blood cells

**Table 4** Multivariate analysis of risk factors for readmission

| Variable | OR | 95% CI | *p* |
|---|---|---|---|
| Female sex | 1.23 | 0.55–2.76 | 0.37 |
| Age, ≥50 years | 3.54 | 1.51–8.30 | **0.003** |
| BMI, >30 kg/m$^2$ | 2.69 | 0.83–8.72 | 0.09 |
| Conversion to open surgery | 0 | – | 0.99 |
| Drainage | 0 | – | 0.99 |
| WBC, >*19*/mm$^3$ | 2.14 | 0.69–6.59 | 0.18 |
| Operative time, >*90* min | 0.62 | 0.13–2.89 | 0.54 |
| Mild peritonitis | 6.16 | 1.80–34.93 | **0.03** |
| Gangrenous/perforated appendicitis | 1.67 | 0.54–5.17 | 0.37 |

$p < 0.05$ are denoted in bold

*BMI* body mass index, *WBC* white blood cells

46% vs. 27%, $p = 0.01$) were more frequent among readmitted patients, as compared to those without readmission. Except for a higher incidence of obesity, similar prevalence of comorbidities was found between readmitted and non-readmitted patients (Table 3). Multivariate logistic regression analysis showed that age ≥50 years (OR 3.54, 95% CI 1.5164–8.30) and mild peritonitis (OR 6.16, 95% CI 1.80–34.93) were independent risk factors for readmission (Table 4).

## Discussion

This study aimed to analyze risk factors for readmission after short-stay LA. We found that: (a) 75% of the patients undergoing LA had a short hospital stay, and (b) age ≥50 years and mild peritonitis were independent risk factors for readmission.

Delayed hospital discharge of surgical patients has not only deleterious economic implications, but it is also associated with increased rate of complications [12–14]. Demographic characteristics of most patients undergoing LA plus the benefits of minimally invasive surgery have made LA an ideal surgery for short hospital stay. Moreover, enhanced recovery protocols for LA can be easily implemented and favor short admissions [3].

Multiple studies have shown the feasibility and safety of short-stay (<24 h) or same-day discharge LA in selected patients [3–9]. For instance, studies by Sabbagh and Lefrancois reported that LOS <24 h was feasible in 52% and 38.7% of patients admitted for acute appendicitis, respectively [15, 16]. Similarly, another study analyzed a consecutive series of 185 LA and found that 58.9% of patients underwent a successful ambulatory management [4]. A recent meta-analysis also concluded that ambulatory LA might be safe in selected patients with acute uncomplicated appendicitis [17]. In addition, Vuagniaux et al. developed a purely clinical predictive score based on five preoperative parameters (gender, ASA score, generalized guarding, C-reactive protein, and leukocyte count) capable of selecting patients for short stay after appendectomy with

a sensitivity and a negative predictive value of 95.6% and 82.2%, respectively [18]. In our series, 75% of all patients admitted for acute appendicitis were discharged within 24 h of the operation. It is worth mentioning that there were 336 (16.7%) patients with severe peritonitis, and none of them were discharged within 24 h of the operation. Interestingly, some of the above-mentioned studies used an ambulatory surgery protocol in which patients diagnosed in late afternoon were sent back home and operated the following day. Controversy exists regarding delays in surgical management of acute appendicitis. While some authors state that the risk of complication or perforation after short delays (<24 h) in operation is low [19, 20], others have reported higher risks of surgical site infection when admission-to-appendectomy time was longer than 6 h [21]. In our series, all patients were promptly operated, no matter the time of the day they were admitted.

Readmission rates after LA range between 1 and 9.2% [22, 23]. For instance, Gignoux et al. reported 4.6% and 11.9% of re-hospitalizations and re-consultations after ambulatory LA, respectively [4]. We found 1.7% of readmissions and 7.9% of re-consultations after short-stay LA. Risk factors assessment could help to determine which patients might benefit from closer monitoring. A large multicenter study analyzed 4618 patients who underwent LA and found that postoperative complications, reintervention, and LA performed by residents were associated with higher rates of readmission [23]. A recent meta-analysis of 836,912 appendicectomies reported a readmission rate of 4.3% and found diabetes mellitus, complicated appendicitis, and open surgical technique as risk factors for readmission [24]. Similarly, a study that analyzed 46,960 patients from the US National Surgical Quality Improvement Program database found that perforated appendicitis, appendicitis with peritonitis, dirty surgical wounds, and preoperative sepsis were associated with unplanned readmission. Most common reasons for readmission were intra-abdominal infections, non-specific abdominal pain, and paralytic ileus [25]. In our study, we determined that postoperative IAA was the most common reason for readmission (69%). We also found that mild peritonitis and age over 50 years were independent risk factors for readmission. Moghadamyeghaneh et al. also found that age was associated with unplanned readmissions [25]. Furthermore, higher rate of perforated appendicitis, worse postoperative outcomes and longer LOS have been reported in elderly patients, mostly related to longer intervals between symptoms' onset and admission as compared to their younger counterparts [26, 27].

The main limitation of this study is its retrospective nature. Although a large series of patients with short hospital stay was included, the relatively low number of patients readmitted may also limit the statistical power of the analysis. However, considering that scarce information is available regarding risk factors for readmission after short-stay LA, we believe our study contributes relevant data to this topic.

## Conclusions

Short hospital stay (<24 h) is safe and feasible in most patients undergoing LA for acute appendicitis. However, patients over 50 years old and/or with localized peritonitis have significantly higher risk of readmission. Considering that the mean time to readmission was 6 days, a closer follow-up during the first week might be reasonable in these patients. Further investigation on this area is necessary as LOS continues to decrease in LA.

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**Compliance with ethical standards**

**Conflict of interest** Cristian A. Angeramo, Nicolas H. Dreifuss, Ayelen A. Olivero, Emmanuel E. Sadava, and Francisco Schlottmann have no conflict of interest, financial ties, or funding/support to disclose.

**Ethical approval** The institutional review board (IRB) approved this study.

**Informed consent** The written informed consent was waived by the IRB owing to the study's retrospective nature.

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