



Conversion from Laparoscopic to Open Appendectomy: Trends, Risk Factors and Outcomes. A 15-Year Single-Center Analysis of 2193 Adult Patients

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Abstract

Background Laparoscopic appendectomy (LA) has become the standard of care for the management of acute appendicitis in adult patients. Despite the increasing experience in laparoscopy, conversion to open surgery might still occur. We aimed to identify preoperative and intraoperative risk factors for conversion and determine surgical outcomes in this population.

Methods We performed a retrospective analysis of a consecutive series of patients undergoing LA during the period 2006–2020. The cohort was divided into two groups: patients who underwent a fully laparoscopic appendectomy (FLA) and patients who were converted to open appendectomy (CA). Demographics, perioperative variables and postoperative outcomes were compared between both groups. Independent risk factors for conversion were determined by logistic regression analysis.

Results A total of 2193 patients were included for analysis; 2141 (98%) underwent FLA and 52 (2%) CA. Conversion rates decreased significantly over time ($p = 0.006$). Patients with CA had significantly higher overall postoperative morbidity rates (FLA 14.9% vs. CA 48.0%, $p < 0.0001$) and longer mean length of hospital stay (FLA 1.7 vs. CA 5 days). In the multivariate analysis, obesity ($p < 0.001$), previous abdominal operations ($p = 0.013$), peritonitis ($p = 0.003$) and complicated appendicitis ($p < 0.001$) were independent risk factor for conversion.

Conclusions Although conversion from laparoscopic to open appendectomy is infrequent and has decreased over time, it is associated with significantly higher postoperative morbidity. Patients with previous abdominal operations, obesity and complicated appendicitis should be thoroughly advised about the higher risk of conversion.

Introduction

Acute appendicitis is one of the most common surgical emergencies worldwide, with an overall incidence of approximately 9 cases per 10,000 population per year in the USA [1]. Laparoscopic appendectomy (LA) has gained wide acceptance in the last decades and has become the preferred treatment modality in adult patients [2–6].

Reduced wound infection rates, faster recovery time and shorter hospital stay are some of the proven advantages of the laparoscopic approach [2–9].

Despite the increasing experience in LA, conversion to open surgery might still occur [3, 8–10]. The decision to convert might be influenced by intraoperative factors such as adhesions, retrocecal appendix or the presence of complicated appendicitis [8–11]. Preoperative variables, however, might also play a role. The awareness of risk factors for conversion may help surgeons to selectively inform patients about the higher chances of conversion and may also encourage the development of strategies to decrease the risk of conversion.

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The aim of this study was to identify preoperative and intraoperative risk factors for conversion and determine outcomes of patients undergoing conversion from laparoscopic to open appendectomy.

Methods

Study design and population

We retrospectively analyzed a consecutive series of patients undergoing LA for acute appendicitis during the period 2006–2020. Patients younger than fourteen years old and those who underwent conventional appendectomy were excluded from the analysis. The sample was divided into two groups: patients with fully laparoscopic appendectomy (FLA) and those who required conversion to open appendectomy (CA). Conversion was defined as the need for either a midline laparotomy or a Mc Burney incision.

Clinical diagnosis of acute appendicitis was supported with abdominal ultrasound and/or abdominal computed tomography (appendicular thickening > 7 mm and peri-appendicular fat stranding) in all cases [12]. All patients diagnosed with acute appendicitis were admitted for surgery within 12 h of the diagnosis regardless the severity of the case. Complicated appendicitis was defined as perforation of the appendix, gangrene, empyema, or abscess formation. Purulent fluid localized in one or more quadrants was defined as peritonitis.

Surgical technique and postoperative care

All the operations were performed by surgical residents and supervised by board-certified surgeons. A laparoscopic three ports technique was used: 10-mm port in the umbilical region, 10-mm suprapubic port and a 5-mm port in the left iliac fossa, lateral to the inferior epigastric vessels. 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. Surgical specimens were sent for histopathological examination in all cases. Peritoneal lavage was performed in all cases of peritonitis. Abdominal drains were used only in selected cases of generalized peritonitis and/or perforated appendicitis.

Patients with gangrenous or perforated appendicitis and/or with peritonitis received antibiotic therapy for 7 days postoperatively. Ambulation and oral feeding with clear liquids were usually resumed when patients were fully awake.

Follow-up was scheduled at clinics on postoperative day 7 and 30. Routine laboratory and imaging studies were not performed unless a postoperative complication was clinically suspected. Postoperative intra-abdominal abscesses were treated with intravenous antibiotics alone, percutaneous drainage or laparoscopic lavage according to our institution treatment algorithm [13, 14].

Data collection

Data analyzed included age, gender, body mass index (BMI), American Society of Anesthesiologists (ASA) score, comorbidities, previous abdominal operations, leukocytosis, grade of appendicitis (normal, inflamed, gangrenous or perforated with peritonitis), severity of peritonitis, operative time, intraoperative complications, postoperative morbidity (Clavien-Dindo classification), mortality, length of stay (LOS) and readmissions.

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

Statistical analysis

For statistical analysis, R version 4.0.4 was used. Continuous variables were compared with Mann–Whitney *U* test or Student's *T* test according to their non-parametric or parametric distribution, respectively. A multivariate logistic regression model was performed to identify independent predictors of conversion. Variables having a significant univariate test at 0.05 level of significance were included for the multivariate analysis. However, as operative time is expected to be always longer in the converted group, we excluded it from the final model. A linear regression model was also used to analyze the relationship between the rates of conversion and time (years). For all statistical methods, a *p* value < 0.05 was considered statistically significant.

Results

A total of 2193 patients were included for analysis; 2141 (98%) underwent FLA and 52 (2%) CA. Gender distribution was similar in both groups. Obesity (FLA 5% vs. CA 30.8%, *p* < 0.001) and previous abdominal operations (FLA 14% vs. CA 27%, *p* = 0.009) were more frequent in converted patients.

A normal appendix was identified in 117 patients (negative appendectomy rate of 5%). Complicated appendicitis (FLA 20.3% vs. CA 82.7%, *p* < 0.0001) and peritonitis (FLA 39.6% vs. CA 92.3%, *p* < 0.0001) were more frequent in CA. Mean operative time was longer in CA (FLA 55.3 vs. CA 111.6 min, *p* < 0.001). Intraoperative

complications were also higher in the CA group (FLA 0.8% vs. CA 3.8%, $p < 0.019$). Preoperative and intraoperative variables are summarized in Table 1.

Conversion rates showed a significant decrease over time ($p = 0.006$) (Fig. 1). Most common reasons for conversion included appendicular base perforation (28.8%), adherences (15.4%), inability to find the appendicular base (11.5%), appendicular plastron (11.5%), and bleeding (3.8%).

Overall postoperative morbidity rates were higher in patients with CA (FLA 14.9% vs. CA 48%, $p < 0.0001$). Clavien–Dindo Grade I, II, IIIa and IV complications were also more frequent in converted procedures. Mean LOS was significantly longer in the CA group (FLA 1.7 vs. CA 5 days, $p < 0.0001$). No mortality was registered (Table 2).

Multivariate analysis showed that BMI ≥ 30 kg/m² (OR 5.02, 95% CI 2.46–9.92, $p < 0.001$), previous abdominal operations (OR 2.42, 95% CI 1.17–4.78, $p = 0.013$), peritonitis (OR 7.50, 95% CI 2.27–34.0, $p = 0.003$), and complicated appendicitis (OR 5.83 95% CI 2.68–14.4, $p < 0.001$) were independent risk factor for conversion (Table 3).

Discussion

The aim of this study was to determine outcomes of patients undergoing CA and to identify risk factors for conversion. We found that: (a) conversion to open surgery is infrequent and has decreased over time; (b) patients with

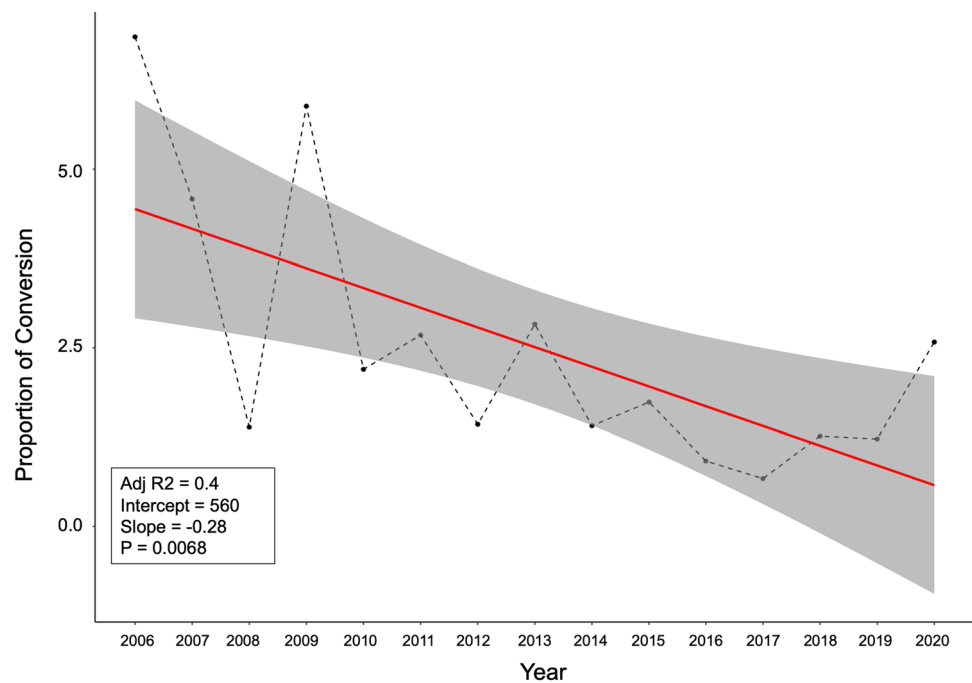
Table 1 Preoperative and intraoperative variables of fully laparoscopic appendectomy (FLA) and converted appendectomy (CA)

	FLA <i>n</i> 2141	CA <i>n</i> 52	<i>p</i>
Sex			0.38
Female, <i>n</i> (%)	1,038 (48.5)	22 (42.3)	
Male, <i>n</i> (%)	1,103 (51.5)	30 (57.7)	
Mean age, (range) years	35.7 (14–93)	43.4 (18–80)	<0.001
BMI > 30, <i>n</i> (%)	109 (5)	16 (30.8)	<0.001
Tobacco use, <i>n</i> (%)	126 (5.9)	8 (15.4)	0.005
Hypertension, <i>n</i> (%)	135 (6.3)	10 (19.2)	<0.001
Coronary artery disease, <i>n</i> (%)	37 (1.7)	0 (0)	0.34
DBT, <i>n</i> (%)	31 (1.4)	0 (0)	0.38
COPD, <i>n</i> (%)	18 (0.84)	1 (1.9)	0.4
Previous abdominal operations, <i>n</i> (%)	299 (14)	14 (27)	0.009
WBC > 10.000/mm ³ , <i>n</i> (%)	1661 (77.5)	44 (84.6)	0.22
ASA score \geq II, <i>n</i> (%)	553 (25.8)	24 (46.1)	0.001
Complicated appendicitis, <i>n</i> (%)	434 (20.3)	43 (82.7)	<0.0001
Peritonitis, <i>n</i> (%)	849 (39.6)	48 (92.3)	<0.001
Operative time, (range) min	55.3 (10–220)	111.6 (40–180)	<0.001
Reason for conversion, <i>n</i> (%)	-		
Appendix base perforation		15 (28.8)	
Appendix base not recognized		6 (11.5)	
Adherences		8 (15.4)	
Appendicular plastron		6 (11.5)	
Bleeding		2 (3.8)	
Others		15 (28.8)	
Intraoperative complications, <i>n</i> (%)	17 (0.8)	2 (3.8)	0.019
Bowel injury	5	1	
Retroperitoneal hematoma	1	1	
Port-site bleeding	10		
Bladder injury	1		

BMI body mass index, DBT diabetes, COPD chronic obstructive pulmonary disease, WBC white blood cells, ASA American Society of Anesthesiologists

$p < 0.05$ are denoted in bold

Fig. 1 Rates of conversion from laparoscopic to open appendectomy from 2006 to 2020



CA had higher postoperative morbidity and longer LOS; and (c) obesity, previous abdominal operations, complicated appendicitis, and peritonitis were independent risk factors for CA.

In the last decades, laparoscopy has been widely embraced for the management of surgical emergencies [3, 6]. Improvements in minimally invasive surgical techniques, technological advances, and surgeons' increasing expertise have given ground for adopting LA as the standard of care for the surgical treatment of acute appendicitis [2–6]. Multiple meta-analyses and randomized controlled trials comparing LA with open appendectomy have demonstrated that LA has several benefits such as less postoperative pain, reduced postoperative ileus, higher cosmetic benefits, and shorter LOS and recovery times [2, 3, 7]. A non-operative management of acute appendicitis with antibiotic therapy has also been promoted. In fact, this approach is supported by evidence showing that a large proportion of patients with non-complicated appendicitis can be safely treated with antibiotic therapy only [15–17]. At our institution, however, we operate on all patients presenting with acute appendicitis.

Conversion rates in LA are variable among the literature and range from 1 to 27% [9, 18–21]. An analysis of the Nationwide Inpatient Sample (1999–2008) including 151,774 patients showed a conversion rate of 7.9% [18]. Similarly, another study including 705 patients undergoing LA showed a conversion rate of 9.7% [9]. In our study, 98% of the patients were successfully treated with laparoscopy (2% conversion rate), which may reflect the

vast experience of our institution in laparoscopic surgery. Moreover, conversion rates had decreased significantly over time. In line with our findings, a population-based and 12-year trend analysis of the Swiss Association of Laparoscopic and Thoracoscopic Surgery reported a conversion rate of 1.58% and also showed a decline in conversion rates over time [19]. Interestingly, in the last year we evidenced a rise in the number of converted appendectomies that may be attributed to the COVID-19 pandemic, in which patients presented with higher rates of complicated appendicitis due to significant delays in consultation [22].

In our series, patients undergoing conversion to open surgery had significantly higher overall postoperative morbidity and longer LOS, as compared to those with FLA. Shimoda and colleagues found that conversion to open surgery resulted in longer operative time, delayed oral intake, and longer LOS [23]. Other studies have also shown that conversion resulted in higher rates of postoperative complications with the need for additional interventions and increased LOS [6, 8, 24].

Our study identified complicated appendicitis and peritonitis as independent intraoperative risk factors for conversion. The appendicular inflammation status seems to be one of the most important factors for conversion in previous studies [4, 10, 23]. For instance, Finnerty et al. developed a predictive scoring model for conversion and found that there was at least a 10–25% risk of conversion if patients had complicated appendicitis [4]. Male gender, elderly patients, ASA score > II, leukocytosis and

Table 2 Postoperative outcomes of fully laparoscopic appendectomy (FLA) and converted appendectomy (CA)

	FLA n 2141	CA n 52	<i>p</i>
Unprogrammed consults, <i>n</i> (%)	212 (9.9)	9 (17.3)	0.08
Readmissions, <i>n</i> (%)	61 (2.8)	1 (1.9)	0.69
Seroma		1	
Intra-abdominal abscess	38		
Dehiscence of the stump	3		
Pulmonary edema	1		
Hemoperitoneum	6		
Wound infection	1		
Septic shock	2		
Fever and abdominal pain	2		
Stump appendicitis	1		
Deep vein thrombosis	1		
Ileitis	1		
Omental infarction	1		
Vomiting	1		
Ileus	1		
Length of stay, (range) days	1.7 (1–27)	5 (1–30)	<0.0001
Clavien-Dindo			
I, <i>n</i> (%)	196 (9.15)	15 (28.8)	<0.001
Fever	57	3	
Wound infection	40	8	
Abdominal pain	38	2	
Ileus	26	2	
Vomiting	16		
Wound hematoma	6		
Diarrhea	5		
Cutaneous rash	3		
Phlebitis	2		
Wound dehiscence	1		
II, <i>n</i> (%)	47 (2.2)	4 (7.7)	0.009
Intraabdominal abscesses	25	1	
Fever	7		
Ileus	4	1	
Wound infection	2	1	
Acute renal failure	2		
Arrhythmia	2		
Deep vein thrombosis	1	1	
Fluid overload	1		
IIIa, <i>n</i> (%)	30 (1.4)	3 (5.8)	0.04
Intraabdominal abscesses	30	3	
IIIb, <i>n</i> (%)	40 (1.9)	1 (1)	0.9
Intraabdominal abscesses	25	1	
Dehiscence of the stump	3		
Hemoperitoneum	5		
Fever	3		
Stump appendicitis	1		
Bladder injury	1		
Omental infarction	1		

Table 2 continued

	FLA n 2141	CA n 52	<i>p</i>
IV, <i>n</i> (%)	8 (0.4)	2 (3.8)	<0.001
Septic shock	4	1	
Desaturation and hypotension	2		
Air embolism			
Pulmonary embolism	1		
Pulmonary edema	1		
Overall morbidity	321 (14.9)	25 (48)	<0.0001
Mortality, <i>n</i> (%)	0 (0)	0 (0)	1

p < 0.05 are denoted in bold

Table 3 Multivariate logistic regression analysis of risk factors for conversion to open surgery

Variables	Conversion		
	OR	95% CI	<i>p</i>
BMI \geq 30 kg/m ²	5.02	2.46–9.92	<0.001
Peritonitis	7.5	2.27–34.0	0.003
Gangrenous or perforated appendicitis	5.83	2.68–14.4	<0.001
Age above 65	0.96	0.35–2.41	0.94
Hypertension	1.59	0.62–3.91	0.32
Tobacco use	1.05	0.39–2.59	0.92
ASA \geq II	0.99	0.46–2.03	0.98
Previous abdominal operations	2.42	1.17–4.78	0.013

p < 0.05 are denoted in bold

peritonitis were also identified as risk factors by other authors [4, 10, 23, 25]. High C-reactive protein levels were also found as an independent risk factor for converted appendectomy [23]. We also identified two preoperative risk factors for conversion: obesity and previous abdominal operations. In obese patients, laparoscopy is undoubtedly more challenging. For instance, the presence of abdominal fat hinders an adequate suction and lavage of peritonitis [26]. Patients with previous abdominal operations often have intraabdominal adhesions that might also limit the laparoscopic approach [9, 27]. Overall, as CA is associated with higher postoperative morbidity, high-risk patients should be advised about the higher chances of conversion and should ideally be operated by senior residents or staff surgeons with more experience in laparoscopic surgery whenever possible.

The main limitation of this study is its retrospective nature particularly susceptible to the effect of bias (i.e., selection and performance bias). In addition, although we analyzed a large cohort of patients, a relatively small number of patients underwent CA. Finally, as residents and surgeons at our institution are vastly trained in laparoscopic

surgery, our results may not be generalizable to other centers.

Conclusions

In centers with vast experience in laparoscopy, conversion to open surgery during LA is infrequent. However, adult patients with previous abdominal operations, obesity, complicated appendicitis and/or peritonitis indeed have a significantly higher risk of conversion. As CA is associated with higher postoperative morbidity, high-risk patients should be thoroughly advised about the higher risk of conversion.

Declarations

Conflict of interest Manuela Monrabal Lezama, María A. Casas, Cristian A. Angeramo, Camila Bras Harriott and Francisco Schlottmann have no conflict of interest, financial ties or funding/support to disclose.

References

- Addiss DG, Shaffer N, Fowler BS et al (1990) The epidemiology of appendicitis and appendectomy in the United States. *Am J Epidemiol* 132(5):910–925
- Athanasiou C, Lockwood S, Markides GA (2017) Systematic review and meta-analysis of laparoscopic versus open appendectomy in adults with complicated appendicitis: an update of the literature. *World J Surg* 41(12):3083–3099. <https://doi.org/10.1007/s00268-017-4123-3>
- Georgios M, Daren S, Kallingal R (2010) Laparoscopic versus open appendectomy in adults with complicated appendicitis: systematic review and meta-analysis. *World J Surg* 34:2026–2040. <https://doi.org/10.1007/s00268-010-0669-z>
- Finnerty B, Wu X, Giambone G et al (2017) Conversion-to-open in laparoscopic appendectomy: a cohort analysis of risk factors and outcomes. *Int J Surg* 40:169–175
- Gupta N, Machado-Aranda D, Bennett K et al (2013) Identification of preoperative risk factors associated with the conversion for laparoscopic to open appendectomies. *Int J Surg* 98(4):334–339
- Shaikh A, Sngarsi A, Shaikh G (2009) Clinical outcomes of laparoscopic versus open appendectomy. *JLS* 13(4):574–580
- Jaschinski T, Mosch CG, Eikermann M et al (2018) Laparoscopic versus open surgery for suspected appendicitis. *Cochrane Database Syst Rev* 11(11):CD001546
- Abe T, Nagaie T, Miyazaki M et al (2013) Risk factors of converting to laparotomy in laparoscopic appendectomy for acute appendicitis. *Clin Exp Gastroenterol* 6:109–114
- Liu SI, Siewert B, Raptopoulos V, Hodin RA (2002) Factors associated with conversion to laparotomy in patients undergoing laparoscopic appendectomy. *J Am Coll Surg* 194:298–305
- Antonacci N, Ricci C, Taffurelli G et al (2015) Laparoscopic appendectomy: which factors are predictors of conversion? A high-volume prospective cohort study. *Int J Surg* 21:103–107
- Hellberg A, Rudberg C, Enochsson L et al (2001) Conversion from laparoscopic to open appendectomy: a possible drawback of the laparoscopic technique? *Eur J Surg* 167:209–213
- Garcia EM, Camacho MA, Karolyi DR et al (2018) ACR Appropriateness Criteria® right lower quadrant pain-suspected appendicitis. *J Am Coll Radiol* 15:S373–S387
- Schlottmann F, Sadava EE, Peña ME et al (2017) Laparoscopic appendectomy: Risk factors for postoperative intraabdominal abscess. *World J Surg* 41(5):1254–1258. <https://doi.org/10.1007/s00268-017-3869-y>
- Laxague F, Schlottmann F, Piatti JM et al (2021) Minimally invasive step-up approach for the management of postoperative intraabdominal abscess after laparoscopic appendectomy. *Surg Endosc* 35(2):787–791
- Podda M, Gerardi C, Cillara N et al (2019) Antibiotic treatment and appendectomy for uncomplicated acute appendicitis in adults and children: a systematic review and meta-analysis. *Ann Surg* 270:1028–1040
- Salminen P, Tuominen R, Paajanen H et al (2018) Five-year follow-up of antibiotic therapy for uncomplicated acute appendicitis in the APPAC randomized clinical trial. *JAMA* 320:1259
- Yang Z, Sun F, Ai S et al (2019) Meta-analysis of studies comparing conservative treatment with antibiotics and appendectomy for acute appendicitis in the adult. *BMC Surg* 19:110
- Worni M, Østbye T, Gandhi M et al (2021) Laparoscopic appendectomy outcomes on the weekend and during the week are no different: a national study of 151,774 patients. *World J Surg* 36:1527–1533. <https://doi.org/10.1007/s00268-012-1550-z>
- Brügger L, Rosella L, Candinas D et al (2011) Improving outcomes after laparoscopic appendectomy. A population-based, 12-year trend analysis of 7446 patients. *Ann Surg* 253(2):309–313
- Agresta F, De Simone P, Leone L et al (2004) Laparoscopic appendectomy in Italy: an appraisal of 26,863 cases. *J Laparoendosc Adv Surg Tech A* 14(1):1–8
- Pushpanathan NR, Hashim MNM, Zahari Z et al (2021) Conversion rate and risk factors of conversion to open in laparoscopic appendectomy. *Ann Coloproctol*. <https://doi.org/10.3393/ac.2020.00437.0062>
- Dreifuss N, Schlottmann F, Sadava E et al (2020) Acute appendicitis does not quarantine: surgical outcomes of laparoscopic appendectomy in COVID-19 times. *Br J Surg* 107(10):e368–e369
- Shimoda M, Maruyama T, Nishida K (2019) Preoperative high C-reactive protein level is associated with an increased likelihood for conversion from laparoscopic to open appendectomy in patients with acute appendicitis. *Clin Exp Gastroenterol* 12:141–147
- Wałędzia M, Lasek A, Wysocki M (2019) Risk factors for serious morbidity, prolonged length of stay and hospital readmission after laparoscopic appendectomy—results from Pol-LA (Polish Laparoscopic Appendectomy) multicenter large cohort study. *Sci Rep* 9(1):14793
- Papandria D, Lardaro T, Rhee D et al (2013) Risk factors for conversion from laparoscopic to open surgery: analysis of 2138 converted operation in the American College of Surgeons National Surgical Quality Improvement Program. *Am Surg* 79(9):914–921
- Angeramo C, Laxague F, Castagnino B et al (2021) Impact of obesity on surgical outcomes of laparoscopic appendectomy: lessons learned from 2000 cases in an urban teaching hospital. *Surg Laparosc Endosc Percutan Tech*. <https://doi.org/10.1097/SLE.0000000000000914>
- Jiann-Ming W, Heng-Fu L, Kuo-Hsin C et al (2007) Impact of previous abdominal surgery on laparoscopic appendectomy for acute appendicitis. *Surg Endosc* 21(4):570–573

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