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Laparoscopic approach in perforated appendicitis: increased incidence of surgical site infection?

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Abstract
Background The role of laparoscopy in the setting of perforated appendicitis remains controversial. A retrospective study was conducted to evaluate the early postoperative outcomes of laparoscopic appendectomy (LA) compared to open appendectomy (OA) in patients with perforated appendicitis.
Methods A total of 1,032 patients required an appendectomy between January 2005 and December 2009. Among these patients, 169 presented with perforated appendicitis. Operation times, length of hospital stay, overall complication rates within 30 days, and surgical site infection (SSI) rates were analyzed.
Results Out of the 169 evaluated patients, 106 required LA and 63 OA. Although operation times were similar in both groups (92 ± 31 min for LA vs. 98 ± 45 for OA, $p = 0.338$), length of hospital stay was shorter in the LA group (6.9 ± 3.8 days vs. 11.5 ± 9.2, $p < 0.001$). Overall complication rates were significantly lower in the LA group (32.1 vs. 52.4 %, $p < 0.001$), as were incisional SSI (1.9 vs. 22.2 %, $p < 0.001$). Organ/space SSI rates were similar in both groups (23.6 % after LA vs. 20.6 % after OA, $p = 0.657$).
Conclusions For perforated appendicitis, LA results in a significantly shorter hospital stay, fewer overall postoperative complications, and fewer wound infections compared to OA. Organ/space SSI rates were similar for both procedures. LA provides a safe option for treating patients with perforated appendicitis.

Keywords Adult · Laparoscopy · Organ space infection · Perforated appendicitis

Appendicitis is one of the most common causes for emergency abdominal surgery, with a reported lifetime incidence of approximately 7 % [1]. Laparoscopic appendectomy (LA) has gradually become a routine procedure, although its efficacy and superiority remain a matter of debate. Several reports suggest that LA provides advantages in terms of shorter hospital stay, less postoperative pain, faster recovery time, and reduced morbidity rate at the expense of longer operating times [2–5]. However, other studies reported no significant advantages for LA compared to open appendectomy (OA), stating that choice of the operative approach should be based on surgeon and patient preference [6, 7].

One of the main controversies lies within the application of LA in the setting of perforation. Perforated appendicitis is inevitably associated with higher postoperative morbidity and mortality rates [8], with one of the most feared postoperative complications being an intra-abdominal abscess. Previous studies have demonstrated that LA for complicated appendicitis may be associated with an increased rate of abscess formation when compared to OA, suggesting caution when using the laparoscopic approach in this group of patients [9–12].

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The aim of this retrospective study was to compare operative results, length of hospital stay, and postoperative early morbidity—with emphasis on infectious complications—between the two procedures in patients treated for perforated appendicitis.

Methods

Patients were identified on the basis of the International Classification of Diseases, 9th revision, Clinical Modification (ICD-9-CM), procedure coding system (codes 47.01, 47.09) from our hospital records. A total of 1,032 consecutive patients aged $\geq$15 years underwent an appendectomy for acute appendicitis between January 2005 and December 2010 at our institution. Retrospective review identified 169 patients with perforated appendicitis included for analysis. Patients with diagnosis other than appendicitis or patients requiring interval appendectomy were excluded. Diagnosis of perforated appendicitis was based on intraoperative findings and not on histological examination. Inclusion criteria were visible perforation with spilling of intraluminal contents and presence of a periappendiceal abscess.

Patients were divided into two groups: laparoscopic or open surgery. Patients in whom the operation was started laparoscopically but then converted were included in the open group.

Basic patient demographics, intraoperative findings, total operation time, length of hospital stay, postoperative morbidity, and mortality were collected. Being a teaching hospital, appendectomies are generally carried out laparoscopically in our institution, so reasons for conversion or primary open approach were additionally analyzed.

The grade of peritonitis was taken from the operation notes and defined as (category A) localized fibrinous peritonitis, (category B) localized abscess or fibrinous peritonitis in up to two quadrants, or (category C) generalized purulent or fibrinous peritonitis in all four quadrants.

OA was performed either via the classical McBurney incision or via a median infraumbilical laparotomy. The appendix was tied at the base and then divided. The appendiceal stump was inverted with a purse-string suture. LA was performed using the three-trocar technique. A 10 mm subumbilical port was introduced using the Hasson technique to create an adequate pneumoperitoneum. Two additional ports (5 and 12 mm), were inserted in the left lower quadrant and either the suprapubic or the right lower quadrant, according to the surgeon's preference. Transection of the appendix was carried out by endostapler, Roeder loop, or clips depending on the thickness and grade of inflammation of the tissue as well as the surgeon's preference. Transection of the mesoappendix was performed by bipolar electrocautery forceps, with any bleeding from larger vessels (e.g., appendiceal artery) controlled with clips. A retrieval bag was used to remove the appendix. Both patient groups underwent thorough peritoneal irrigation using several liters of warm saline until the drainage fluid was clear. Drains were placed according to the preference of the surgeon. Primary skin closure was performed in all cases.

Patients received a standard regimen of intravenous cefazolin 2 g and metronidazole 500 mg before surgery. Postoperatively, antibiotic treatment was continued in accordance with our institutional guidelines: 24 h amoxicillin/clavulanic acid for localized peritonitis and a minimum of 5 days' piperacillin/tazobactam for generalized peritonitis or immunodeficient patients.

Oral intake was started postoperatively as soon the patient could tolerate it. Patients were discharged once bowel function and oral intake were adequate.

Postoperative 30-day morbidity was recorded. In the absence of any complications, surgical follow-up was not routinely planned after discharge.

Overall postoperative morbidity included infectious, cardiovascular, pulmonary, urological, and gastrointestinal complications. Primary end points were surgical site infections (SSI), including incisional SSI and organ/space SSI according to the definition of the United States Centers for Disease Control and Prevention [13]. Additionally, complications encountered in the converted cases were separately analyzed and compared to those of a primary open approach.

Continuous variables were expressed as mean $\pm$ standard deviation and analyzed by unpaired t test. Categorical data were compared by 2×2 χ^2 analysis or Fisher's exact test, as appropriate. A p value of <0.05 was considered statistically significant. Variables potentially associated with organ/space SSI were entered in a univariate analysis. In case of significance, data were further analyzed by multivariate analysis. Statistical analysis was performed by SPSS software, version 17.0 (SPSS, Chicago, IL, USA).

Results

Of the 1032 patients analyzed during the study period, 169 were diagnosed with perforated appendicitis (16.4 %). Sixty-three patients underwent OA and 106 patients LA. Patients in the open group were significantly older (56 vs. 42 years, $p < 0.001$) and had a higher American Society of Anesthesiologists (ASA) class (ASA III–IV, 19 %, vs. ASA I–II, 7.5 %; $p = 0.046$) compared with LA. There were no significant differences with respect to gender distribution and infection-related risk factors, such as history of diabetes mellitus or steroid use. Patient demographics are summarized in Table 1.

Table 2 summarizes intraoperative data. The main reasons for primary OA ($n = 22$) were abnormalities of cardiac output or pulmonary function (40.9 %, $n = 9$), preoperative clinical evaluation suggesting the presence of generalized peritonitis (27.3 %, $n = 6$), or previous abdominal surgery (13.6 %, $n = 3$). There were 41 conversions, 5 (12.2 %) due to adhesions, 10 (24.4 %) due to generalized purulent peritonitis, 19 (46.3 %) due to inflammatory conglomerate tumors in the cecal region, and 7 (17.1 %) due to localized abscesses. No conversion was necessary due to intraoperative complications.

Mean operation time was 92 ± 31 min in the laparoscopic group and 98 ± 45 min in the open group ($p = 0.338$). The incidence of localized peritonitis, localized abscess or fibrinous peritonitis up to two quadrants, and generalized peritonitis in all four quadrants was equivalent in all groups. The majority of open procedures were performed through a midline infraumbilical laparotomy (92 %, $n = 58$). Transection of the appendix during LA was mostly performed with an endostapler (67 %, $n = 71$). Intraoperative complications included one patient with intestinal injury in each group.

Postoperative details are listed in Table 3. Length of hospital stay was significantly shorter after LA (6.9 ± 3.8 vs. 11.5 ± 9.2 days, $p < 0.001$). The overall complication rate was significantly higher in the open compared to the laparoscopic group (52.4 vs. 32.1 %, $p < 0.009$). More specifically, incisional SSI were significantly less common in LA compared to OA (1.9 vs. 22.2 %, $p < 0.001$) as well as urinary, pulmonary, and cardiovascular complications ($p = 0.018$, $p = 0.026$ and $p = 0.014$, respectively). No difference in gastrointestinal complications was observed between LA and OA. The occurrence of organ/space SSI was similar between LA and OA (23.6 vs. 20.6 %, $p = 0.657$). Mortality was zero after LA; three patient deaths were recorded in the open group (4.8 %, $p = 0.05$).

Organ/space SSI was similarly encountered in both converted and primary open cases (19.5 vs. 22 %, $p = 0.755$). Although there was a trend toward reduced incisional SSI after the primary open approach compared to the converted group, this was not statistically significant (13.6 vs. 26.8 %, $p = 0.343$). Presence of pulmonary (18.2 vs. 2.4 %, $p = 0.046$) and cardiovascular (22.7 vs. 4.9 %, $p = 0.044$) complications was significantly higher in primary OA compared to the converted group.

Among the 25 patients who developed an organ/space SSI after the laparoscopic procedure, 16 required reoperation, 8 were treated with computed tomographic-guided placement of a percutaneous drain, and 3 were managed conservatively with antibiotics alone. Eight out of 13 patients with organ/space SSI in the open group required surgical reexploration, the other patients were treated with drain placement alone.

Evaluation of age, gender, ASA score, history of diabetes, steroid medication, surgical method applied, conversion, grade of peritonitis, and operation times did not reveal significant risk factors for organ/space SSI in univariate analysis (Table 4).

Table 1 Patient demographics

Characteristic	Laparoscopic group	Open group[a]	*p*
Total group	106 (62.7 %)	63 (37.3 %)	
Male gender	64 (60.4 %)	38 (60.3 %)	0.99
Age, years, mean ± SD	42 ± 19	56 ± 22	<0.001
History of diabetes mellitus	3 (2.8 %)	4 (6.3 %)	0.426
Steroid use	8 (7.6 %)	6 (9.5 %)	0.774
ASA class			0.046[b]
I	77 (72.6 %)	28 (44.4 %)	
II	21 (19.8 %)	23 (36.5 %)	
III	7 (6.6 %)	11 (17.5 %)	
IV	1 (0.9 %)	1 (1.6 %)	

SD standard deviation, *ASA* American Society of Anesthesiologists

[a] The open group includes converted procedures

[b] Denotes comparison between ASA class I–II and III–IV

Discussion

Perforated appendicitis is associated with an increased risk of postoperative complications and has previously been considered a relative contraindication for laparoscopic surgery [14, 15]. We believe that it is precisely in the setting of perforation that the well-known advantages of LA can be of great use. LA, besides being a valuable diagnostic tool, allows better visualization of the entire abdominal cavity, thorough irrigation under visual control and avoidance of large incisions.

Our study encompassed a period during which laparoscopic surgery was already routinely practiced in our institution for treatment of acute appendicitis. In our report, operating times were similar between the two procedures, which probably reflects the surgical team's experience. The high conversion rate may be explained by our general surgical protocol, which recommends a primary laparoscopic approach even in patients with suspected complicated appendicitis. The documented conversion rate for perforated appendicitis corresponds to previously published data [16]. Acute appendicitis was mainly diagnosed clinically with full

Table 2 Intraoperative data

Characteristic	Laparoscopic group	Open group[a]	*p*
Operation time, minutes, mean ± SD	92 ± 31	98 ± 45	0.338
Grade of peritonitis			0.486[b]
Localized fibrinous peritonitis (category A)	38 (35.8 %)	16 (25.4 %)	
Localized abscess or fibrinous peritonitis up to two quadrants (category B)	39 (36.8 %)	26 (41.2 %)	
Generalized purulent or fibrinous peritonitis (category C)	29 (27.4 %)	21 (33.3 %)	
Midline laparotomy	–	58 (92 %)	NA
Use of stapler	71 (67 %)	–	NA

SD standard deviation, *NA* not applicable

[a] The open group includes converted procedures

[b] Denotes comparison between category A/B and C

Table 3 Postoperative data

Characteristic	Laparoscopic group	Open group[a]	*p*
Length of hospital stay, days, mean ± SD	6.9 ± 3.8	11.5 ± 9.2	<0.001
Length of hospital stay for patients who developed an organ/space SSI, days, mean ± SD	9.9 ± 4.8	10.9 ± 7.5	0.647
Overall complications[b]	34 (32.1 %)	33 (52.4 %)	<0.001
Incisional SSI	2 (1.9 %)	14 (22.2 %)	<0.001
Organ/space SSI	25 (23.6 %)	13 (20.6 %)	0.657
Urinary complications	0	4 (6.3 %)	0.018
Pulmonary complications	1 (0.9 %)	5 (7.9 %)	0.027
Gastrointestinal complications	5 (4.7 %)	5 (7.9 %)	0.503
Cardiovascular complications	2 (1.9 %)	7 (11.1 %)	0.014
Mortality	0	3 (4.8 %)	0.05
Treatment for patients who developed an organ/space SSI			
Reoperation	16 (64 %)	8 (61.5 %)	1
Laparoscopy	9	0	NA
Laparotomy	9	8	NA
Percutaneous drainage	8 (32 %)	5 (38.5 %)	0.730
Antibiotic alone	3 (12 %)	0	0.538

SSI surgical site infection, *SD* standard deviation, *NA* not applicable

[a] The open group includes converted procedures

[b] Complications within 30 days

history and physical examination, and preoperative ultrasonography or computed tomography were performed selectively in case of equivocal symptoms. Because of this policy, it would be unlikely that the surgeon could predict the status of appendicitis before operation and prefer an open approach in case of perforated appendicitis.

Median umbilical–pubis incision was the preferred approach in our study for both primary OA and conversion after unsuccessful LA. This incision allows a better visualization and offers the opportunity to be enlarged in both directions in case of unexpected pathology and should be preferred in case of conversion because of complicated appendicitis [17]. The significantly higher rate of incisional SSI in OA compared to LA is explained by the increased wound surface area, which is in potential contact with the infected fluids. Previous studies have shown similar wound infection rates [18, 19]. The smaller incisions associated with the laparoscopic approach, combined with the use of a retrieval plastic bag to remove the appendix, greatly reduce the risk of local wound contamination. Our findings do not demonstrate a significant difference in the rate of organ/space SSI between the open and the laparoscopic approach. In our series, the mortality rate in the open group was 4.8 % and correlated with the presence of comorbidities and age. In addition, all deaths were encountered in the primary open group. Two 93-year-old women died of systemic sepsis with multiple organ failure, while one 80-year-old man died of pneumonia. These results are in

Table 4 Univariate analysis of clinical factors associated with organ/space SSI

Characteristic	OR (CI 95 %)	*p*
Male gender	1.281 (0.614–2.669)	0.509
Age >60 years	0.527 (0.223–1.246)	0.140
ASA class III/IV	0.575 (0.159–2.077)	0.393
History of diabetes mellitus	0.479 (0.057–4.108)	0.488
Steroid use	0.672 (0.141–3.209)	0.616
Laparoscopic technique	1.187 (0.557–2.531)	0.657
Conversion	0.792 (0.330–1.898)	0.600
Grade of peritonitis C	0.565 (0.239–1.338)	0.191
Operation time >95 min	1.281 (0.614–2.669)	0.509

SSI surgical site infection, *ASA* American Society of Anesthesiologists, *OR* odds ratio, *CI* confidence interval

agreement with previous reports and highlight the fact that surgery for perforated appendicitis remains a potentially high-risk operation with a nonnegligible mortality rate [20–23].

One of the main advantages of LA in the setting of perforated appendicitis is a significant reduction in length of hospital stay of approximately 4.5 days compared to the open approach. In an era in of increasing efforts to reduce health care costs, such a result provides a significant benefit for patient and hospital alike. The hospital stay was longer for patients who developed septic complications, but, importantly, subgroup analysis of patients developing either incisional SSI or organ/space SSI showed a similar length of hospital stay (data not shown). Incisional SSI may not be as life-threatening a complication as organ/space SSI, but it represents an equal inconvenience to the patient, involving a longer convalescence time and a longer time off work.

Despite our retrospective approach, data collection was complete, with no patients needing to be excluded as a result of missing data. Because of the retrospective nature of this study and the infeasibility of adopting an intention-to-treat analysis as a result of our protocol mandating a primary laparoscopic approach in patients with suspected appendicitis, a certain selection bias with regard to the choice of the primary surgical approach cannot be excluded and may have affected the results. Interestingly, as shown by subgroup analysis of complications occurred after open procedures, secondary conversion had no negative effect on perioperative morbidity. Baseline clinical differences between patients in the laparoscopic and open groups were detected in our series; nevertheless, on univariate analysis, none of the variables was found to be a significant risk factor for the development of organ/space SSI. A further limitation of this study is the relatively small sample size. However, previous studies have indicated that more than 2000 patients with perforated appendicitis would be required in order to achieve statistical significance in analysis of intra-abdominal abscess rate, constituting for a single institution an impractical task [24, 25].

In conclusion, we were able to demonstrate the superiority of a laparoscopic approach in patients with perforated appendicitis with regard to length of hospital stay and overall postoperative complications. Furthermore, LA results in significantly fewer incisional SSI and similar organ/space infection rates compared to OA and remains a safe and valid procedure for patients with perforated appendicitis.

Disclosures Raffaele Galli, Vanessa Banz, Hartwig Fenner, and Juerg Metzger have no conflicts of interest or financial ties to disclose.

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