Laparoscopicvs open appendectomy in the management of appendicitis complicated by generalized peritonitis: a prospective randomized trial

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Background
Laparoscopic appendectomy (LA) is performed worldwide in the treatment of acute appendicitis (AP), even if complicated by localized peritonitis. However, the role of the LA in the treatment of AP complicated by generalized peritonitis (GP) is yet controversial. The present study aimed to highlight the efficacy and safety of the laparoscopic approach in AP complicated with GP.
Settings
This study took place in Mansura University Hospital, Faculty of Medicine.
Patients and methods
From September 2010 to May 2019, the patients were randomly assigned to undergo either an LA or exploratory open appendectomy (EOA). The demographics of the patient and preoperative parameters, including radiological evaluation, intraoperative finding, and postoperative complications, were evaluated. The follow-up period was 8 months to 2 years (mean: 18 months).
Main outcomes
The primary outcome of this study was early postoperative complications.
Results
A total of 120 patients, aged 38±11 years, were analyzed. Of these, 69 (57.5%) patients underwent LA, whereas two (2.9%) were converted to open surgery. All patients presented with diffuse peritonitis. The duration of operation was longer in the laparoscopic group than in the EOA group (P=0.001). No differences were detected in the preoperative patient comorbidities. The rate of postoperative surgical infection and intra-abdominal abscess was similar in the laparoscopic and EOA groups (P=0.3040 and 0.0754, respectively). However, the length of hospital stay was shorter in the laparoscopic group than that in the EOA group (P=0.001).
Conclusions
The laparoscopic approach for appendicitis complicated by GP is better than the open approach, and hence, it must be the first choice for surgery in the case of clear preoperative diagnosis.

Keywords:
appendicitis, laparoscopic appendectomy, open appendectomy, peritonitis

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Introduction

Acute appendicitis (AP) is one of the most common abdominal emergencies; up to 10% of the patients present with peritonitis and critical condition [1]. The open approach by McBurney is the standard care for noncomplicated appendicitis [2]. The advantages of laparoscopic appendectomy (LA) with respect to a short hospital stay, less postoperative wound complications, and good cosmetic results have been validated since its introduction by Semm [3]. Laparoscopic exploration is also accepted as a diagnostic tool in conflicting abdominal pain despite extensive radiological evaluation, especially in young women and obese patients [4]. Recently, LA has become the first choice for the treatment of AP despite the diagnosis of complicated disease [5]. However, standardization of the surgical option for appendicitis associated with generalized peritonitis (GP) is yet controversial owing to the lack of consensus and heterogenicity of variable measurements and weak methodology used in randomized trials [6]. Moreover, several postoperative complications, including residual intra-abdominal abscess (IAA), associated with a long hospital stay, intervention, and increased hospital cost ensue [7]. Thus, in this prospective study, we presented

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our experience in laparoscopic approach for the treatment of appendicitis complicated with GP in comparison with the open approach.

Patients and methods

Setting

Consecutive patients treated for complicated AP disease at Mansoura University Hospital (Mansoura, Egypt) from September 2010 to May 2019 were eligible for this study. Informed consent was obtained from all patients after explanation of the nature of the disease and possible treatment. The study was approved by the Local Ethical Committee.

Outcome measures

The primary outcome measure in this study was the postoperative complications, including IAA collection or formation, wound infection, and reoperation.

Inclusion criteria

All patients with complicated AP were diagnosed by preoperative clinical assessment (generalized abdominal tenderness and guarding) and radiological modalities [abdominal sonography (US) and computed tomography (CT)]. Complicated appendicitis represents that all patients with perforated appendicitis presented GP.

Exclusion criteria

The exclusion criteria included pregnant patients or any patient with appendicular mass, appendicular abscess, or localized peritonitis. These manifestations were amenable to either traditional laparoscopic/open management and conservative or radiological therapy.

Interventions

A total of 130 patients were randomized into two groups: 75 in group 1 underwent laparoscopic exploration and appendectomy, and 55 in group 2 underwent exploratory open appendectomy through midline laparotomy incision. The surgical treatment options, complication rates, and hospitalization factors were analyzed (Fig. 1).

Follow-up

All patients were followed up in the early postoperative period to assess the normal bowel function, wound complication, and systemic or localized complication in the form of early postoperative intestinal obstruction, prolonged ileus, surgical site infection, abdominal signs of collection, or residual IAA formation. On the contrary, intraoperative complications, conversion rate, operative time, length of hospital stay, and 30-day mortality were recorded as secondary end points. The follow-up examinations were made at the outpatient clinic or by phone call after surgery. After 1.5 years, the patients were monitored by phone calls at every 6 months. Long-term follow-up for complications, such as intestinal obstruction and the incisional hernia was reported.

Sample size

To guarantee adequate statistical power, the sample size was calculated, and 120 patients were analyzed. The reported incidence of complicated perforated appendicitis was 20% with 0.07 error at 80% power and a 5% confidence level.

Randomization and allocation to intervention

All patients were subjected to careful history taking, clinical examination, laboratory tests, and radiological assessment, including CT. Randomization was achieved through a computer-generated protocol, and the results were sealed into envelopes. These envelopes were opened in the operating room by a nurse who was not engaged in the study (Fig. 1).

The statistical analysis of data was carried out using Excel and SPSS version 10 (SPSS Inc., Chicago, Illinois, USA) to test the statistically significant difference between the groups. The quantitative data were represented as mean±SD for data and as frequency and proportion for qualitative data. The analysis of the data was done. For the quantitative data, Student's t-test was used to compare between two groups. A paired sample t-test was employed to compare one group at different time points. A χ^2-test was used for qualitative data. Correlation co-efficiency was analyzed by detecting the association between variables. P less than or equal to 0.05 is significant at 95% confidence interval.

Surgical procedure

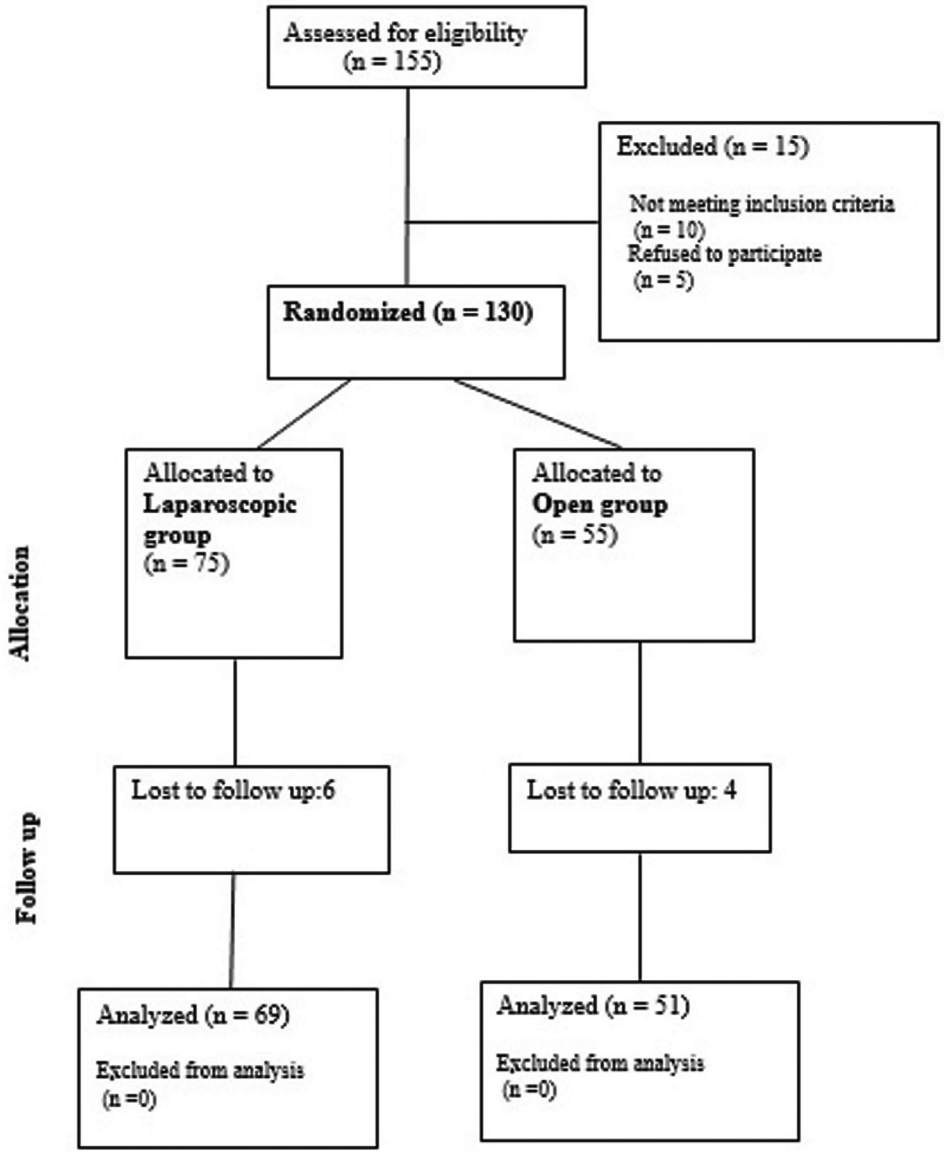
Perioperative preparation

Upon admission, parameters such as resuscitative plane of intravenous fluids, starting broad-spectrum antibiotics with anaerobic coverage, nasogastric decompression if clear preoperative ileus was evident, and urinary catheter for monitoring adequate resuscitation were assessed as a prerequisite for operative intervention. The early consultation of the other medical faculties and anesthesiologists was sought in the management of patients with medical comorbidities for appropriate perioperative optimization.

Laparoscopic exploration and appendectomy

The standard laparoscopic method was applied in all patients except in the case of insertion of an extra port. The abdominal region was accessed with the Hasson's

Figure 1



Flowchart of the patient randomization.

open technique with gas insufflations. Three trocars with a telescope were inserted in the umbilical port and two 5-mm ports in the suprapubic and left iliac fossa, respectively. If pus was accessed, we drained it as much as possible to facilitate further insertion of the remaining ports and intestinal manipulation. If thick pus or pus between intestinal loops was encountered after inserting the left trocar, the abdomen was thoroughly lavaged in the four quadrants to facilitate further management. All fluids were sent for culture and sensitivity for the administration of appropriate antibiotics.

After initial exploration and defining the pathology, peritoneal lavage, control of mesoappendix was done by Liga-sure sealing devise, endoclips, or bipolar diathermy. The appendicular stump was secured by double endoloop, intracorporeal suturing ligation, or endo-GIA (a 12-mm port was inserted instead of the 5-mm port). The final abdominal lavage was applied with copious amounts of saline. These specimens were evaluated pathologically (Figs 2–5).

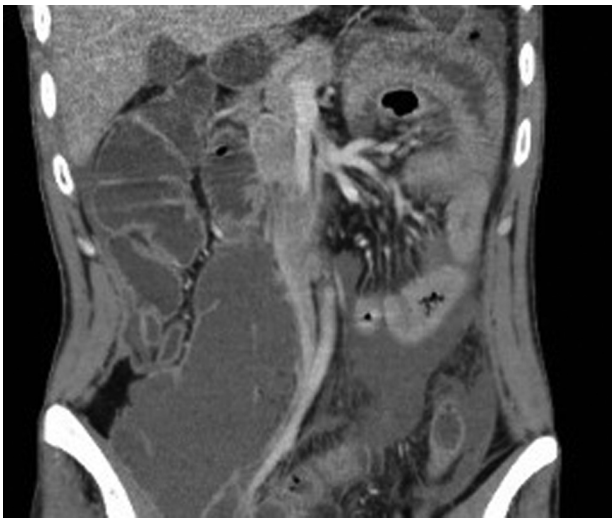
Open exploration and appendectomy

An exploratory open appendectomy was done by a midline incision. Exploration with control of appendicular stump and abdominal lavage was done.

Postoperative care

All patients were kept on a fluid replacement until the abdominal sound was regained, and then, a progressive diet was started. Most of the nasogastric tubes were removed (if inserted preoperatively) in recovery or on the first postoperative day.

Figure 2

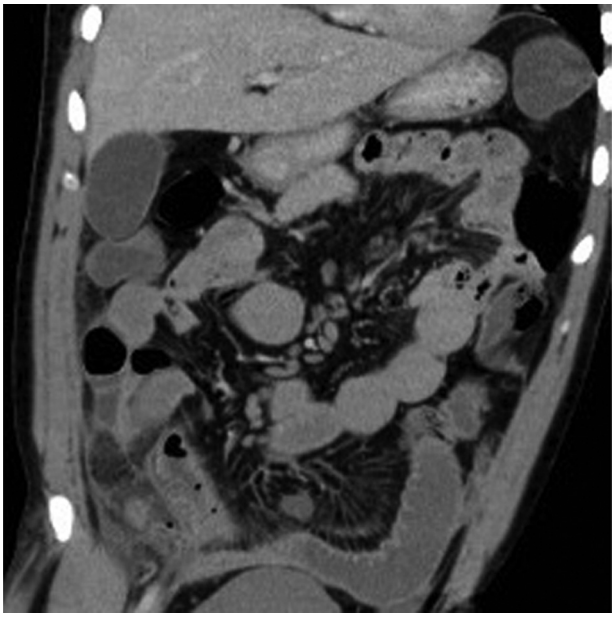


Computed tomography of the abdomen showed diffuse peritonitis and thickened intestinal loops due to ileus.

Figure 3

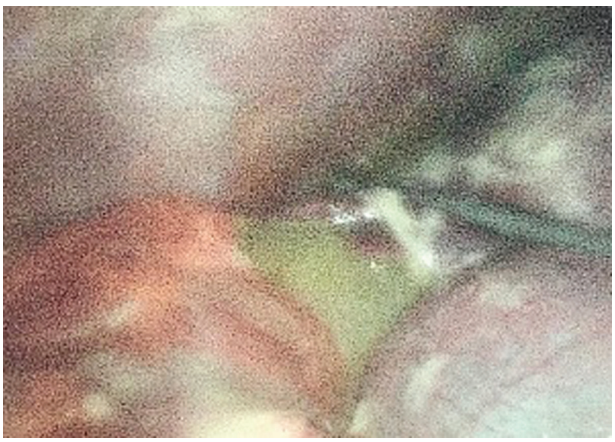
Computed tomography of the abdomen showed perforated appendicitis with generalized peritonitis.

Figure 4



Marked inflammatory change due to appendicitis in the right iliac fossa with intestinal ileus.

Figure 5



Proper laparoscopic peritoneal suction and lavage was an essential step to decrease the incidence of postoperative intra-abdominal abscess.

Moreover, urinary catheters were removed as soon as the patient was ambulated. All patients were administered analgesia regularly for the first 2 days in the form of paracetamol infusion every 8 h, and subsequently, according to the pain scale.

Typically, the abdominal drains in both approaches were removed in the index hospital when daily drainage is minimal and clear. Patients who were admitted to the ICU or high dependency unit were managed similarly. All postoperative specimens were either from preoperative diagnosis of acute, acute perforated, or acute gangrenous appendicitis.

Results

A total of 155 patients were enrolled in this study. Of these, 130 were randomized into either laparoscopic or open approach groups, and 10 patients were lost to follow-up; therefore, 120 were available for the analysis. Both groups were comparable with respect to age, sex, and preoperative laboratory results, including the white blood cell counts (Table 1). A significant difference was detected in the BMI between the two groups ($P<0.0001$). Intriguingly, the overall preoperative comorbidities were similar in both groups. Specifically, seven (5.8%) patients were included with neurological, psychiatric, and congenital disorders

Table 1 Patients' demographic data

Variables	Laparoscopic (*n*=69) [*n* (%)]	Open (*n*=51) [*n* (%)]	*P* value
Age (years)	40.7±10.7	34±10	0.0009
Male	47 (68.1)	37 (72.5)	
BMI (kg/l^2)	32.3±3.5	27.2±3.2	<0.0001
Co-morbidities			
Diabetes mellitus	3 (4.3)	2 (3.9)	NS
Asthma	1 (1.5)	1 (1.96)	
Hypertension	1 (1.5)	1 (1.96)	
Cardiac disease	0	1 (1.96)	
Psychiatric disease	2 (2.9)	1 (1.96)	
Neurological disease	2 (2.9)	1 (1.96)	
Down's syndrome	1 (1.5)	0	
WBCs (U/dl)	16.1±1.5	16.3±1.6	NS

WBC, white blood cell.

Table 2 Short-term outcomes

Variables	Laparoscopic (*n*=69) [*n* (%)]	Open (*n*=51) [*n* (%)]	*P* value
Primary endpoints (SC)			
Intra-abdominal abscess	6 (8.7)	2 (3.9)	0.3040
Surgical site infection	4 (5.8)	8 (15.7)	0.0754
Reoperation	1 (1.5)	2 (3.9)	0.1756
Secondary endpoints			
Readmission	0	1 (1.96)	
30-day mortality	0	0	
ICU admission	1 (1.5)	0	
Conversion	2 (2.9)	0	
Operative time (min)	109.6±23	80.8±8.5	<0.001
Length of hospital stay (days)	7±1.8	10±2.9	0.001

SC, surgical complication.

(Down syndrome) and assigned randomly to both groups. These patients were referred to our facility from the Psychiatric Health Hospital. The consent for the operation was obtained from family members and medical caregivers after full counseling.

One patient presented with diabetic ketoacidosis, which mandated preoperative ICU admission and perioperative treatment until full recovery. Twelve patients (five in the open group and seven in the laparoscopic group) experienced dehydration and electrolyte imbalance that was managed preoperatively in the high dependency unit. No mortality occurred in this study.

One intraoperative complication in the open group occurred, in which failure of safe dissection with severe cecal inflammation and impending perforation mandated the intraoperative decision of limited right hemicolectomy and ileoascending anastomosis. Two conversions in the laparoscopic group occurred: one owing to failure of access and the other owing to severe inflammation and adhesion obscuring anatomical identification. Furthermore, two major complications occurred in the open group and required early reoperation. The two patients presented early postoperative small bowel obstruction; one was already discharged and returned with massive obstruction, and the other had acute abdomen owing to suspected leak. In the laparoscopic group, only one patient was re-explored for a decline in the hemoglobin level and suspected internal hemorrhage, which was managed by open exploration and securing the bleeding appendicular artery. Moreover, no significant difference was detected in the postoperative infection rate in the laparoscopic group (six IAA; two were drained by CT-guided drainage, and the others treated conservatively with antibiotics). Furthermore, four wound infections in the laparoscopic method group vs eight wound infections in the open group mandated the bedside open drainage and dressing, whereas two small IAAs were managed with antibiotics (Table 2). However, no significant difference was detected between both groups with respect to long-term follow-up parameters (Table 3).

Discussion

The present randomized trial compared the laparoscopic with the exploratory open approach in appendicitis

Table 3 Long-term outcomes

Variables	Laparoscopic (*n*=69) [*n* (%)]	Open (*n*=51) [*n* (%)]	*P* value
Incisional hernia	0	2 (3.9)	0.17
Mechanical bowel obstruction	1 (1.4)	3 (5.9)	0.23

complicated with frank peritonitis in some critically ill patients. A meta-analysis studies showed similar results between laparoscopic and open approach for the treatment of AP, rendering that laparoscopy is not universally accepted as the first surgical option as the open approach carries several advantages, such as small incisions and enhanced surgical experience. However, these findings applied only to noncomplicated appendicitis or that with simply localized peritonitis [8–10]. Previous studies showed a high incidence of residual intraabdominal collection and abscess, which was against the standardization of LA as a surgical option like laparoscopic cholecystectomy for cholelithiasis [7,11]. However, a recent meta-analysis demonstrated the efficacy of the laparoscopic approach regarding low postoperative wound infection and short hospital stay with an insignificant difference in the rate of residual abdominal collection and reoperation, especially in adult patients [5]. Although the laparoscopic approach requires a prolonged operative time, a comparable result prompted the investigation of the safety and feasibility of laparoscopic treatment in obese, psychiatric, and co-morbid patients to facilitate comfortable postoperative management for the surgeons [12].

The postoperative surgical site infection, residual intraabdominal collection, and abscess formation have been universally accepted as the parameters of choice for the comparison of both procedures. In this study, no significant difference was detected between the two groups. Notably, these complications did not exceed grades I and II, according to Dindo's classification of surgical complications [13]. We found that good intraoperative abdominal lavage was a key to avoiding such complications. The abdominal drains were used in all patients; however, the correlation is not clear, necessitating additional studies. Our results were correlated well to the work of Katkhouda *et al.* [3] and Klingler *et al.* [14] for both postoperative wound infection and the development of IAA. On the contrary, a recent study by Ingraham *et al.* [15] postulated that the laparoscopic group had low overall infectious complications except for intraabdominal collection and abscess (6.3 vs 4.8%; odds ratio: 1.35; 95% confidence interval: 1.05–1.73). The role of antibiotics and minimally invasive drainage for such residual collection cannot be overlooked, as most patients in these studies were treated conservatively. Notably, reoperation was done in our study for three patients, and none of them was owing to the aforementioned complications, rendering such concern about laparoscopic complications to be revised.

The operative time is long for LA [16–19]. This observation could be attributed to the additional step in the laparoscopic approach required intraoperatively, such as insufflation, precise instrumental insertion to ovoid vascular and bowel injuries, and appropriate exploration and peritoneal lavage. Diathermy injury to the bowel and vascular injury during abdominal access is not uncommon [3]. In the current study, the operative time was prolonged for accurate lavage in the laparoscopic group. We found that the presumed long operative time was compensated for easy postoperative patients handling, especially in those patients with special circumstances and also reflected well on long-term follow-up.

The conversion rate for laparoscopic appendectomies to open approach is around 5% and is dependent on independent factors, such as age greater than or equal to 40 years, male sex, obesity, increased white blood cells, preoperative comorbidities, and presence of GP [20–23]. In this study, only two (2.9%) cases were converted which is low when compared with the other studies [17,24]. We do not count conversion as a procedure failure especially in these type of critical patients as safety of patients cannot be overlooked.

The most critical point in the laparoscopic approach for such patients with GP is the presence of preoperative bowel ileus and so expected difficult abdominal access and decreasing the space of work which may produce bowel injures. To overcome these difficulties in our study, we used open Hasson technique for abdominal access with initial drainage of the most abdominal collection by either suction or suction lavage. We noticed that intestinal caliber and motility started to regain even by the end of the procedure. No bowel injuries were reported in our series, either iatrogenic or during dissection.

One of the optimal parameters for the operative assessment and postoperative outcomes is the length of hospital stay. The study by Biondi *et al.* [25] found a short hospital stay for the laparoscopic group as compared with the prolonged duration required for

the open approach. This finding was correlated with that described previously [26–28]. Conversely, some studies demonstrated no significant differences in terms of hospital stay between the two groups [3,29]. We observed that patients were discharged early in laparoscopic group in spite of long operative time, probably owing to early return of bowel function and less analgesia requirement.

Thereaux *et al.* [24] conducted a study with one of the largest series on appendicitis complicated with GP. The study concluded that LA is feasible and safe in such a critical condition. Moreover, the conversion rate was 3.5%, which was similar to our results (2.9%). The IAA was 7.1%, which was similar to that in the current study (8.7%). The same was applied to the overall infection rate and hospital stay. Our operative time was longer than their study (109.6±23 vs 80±27 min, respectively). Thus, this phenomenon could be ascribed to all our patients with GP, including all the abdominal quadrants.

In this study, no postoperative hernia occurred in the laparoscopic group as compared with two patients in the open approach, rendering the long-term outcome as safe with respect to the laparoscopic approach. The same was applied for mechanical obstruction; only one patient was readmitted late in the laparoscopic group and treated conservatively. Taken together, the laparoscopic approach was safe, showing fewer complications owing to less postoperative adhesion.

Lastly, to conduct our study on a specific population, we contacted referring hospitals around our Central University Hospital. Nevertheless, the current study has some limitations. First, the postoperative pain was not assessed as per our protocol, and a fixed dosage was administered owing to the critical situation of the patient. Second, the lack of evaluation of the financial costs of LA might cause a great burden on low- to moderate-income countries as compared with open surgery.

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Conflicts of interest
There are no conflicts of interest.

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