A prospective comparative study on appendectomy for complicated acute appendicitis via open versus laparoscopic approach

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Introduction
One of the most common causes of lower abdominal pain encountered in the emergency room is acute appendicitis. It is the most common cause of acute abdomen in young patients. Complicated appendicitis includes perforated, gangrenous appendicitis, peri-appendicular mass, or abscess. Appendectomy for acute appendicitis is the standard treatment.

Objectives
The aim of this study was to compare open and laparoscopic appendectomy in the management of complicated acute appendicitis with respect to operative outcomes, including operative time and intraoperative complications, and postoperative outcomes, including start of oral intake, length of hospital stay, return to normal activities, and early postoperative complications as wound infection, and postoperative sepsis and ileus.

Patients and methods
This is a prospective randomized controlled clinical trial performed from June 2021 to June 2022. The study included 50 patients with complicated acute appendicitis. Patients were divided into two groups according to the type of the procedure done for appendectomy whether open or laparoscopic. Each group included 25 patients. Randomization was done using the closed envelope method.

Results
The mean operative time was statistically higher in the laparoscopic group, with a *P* value less than 0.001. There was no statistically significant difference between both groups regarding start of oral feeding and hospital stay. The mean duration of return to normal activity and the rate of wound infection were statistically higher in the open group.

Conclusion
Laparoscopic appendectomy is a safe and feasible surgical option for complicated acute appendicitis. Despite having more operative time, it has less rate of postoperative complications with early return to normal activity.

Keywords:
acute appendicitis, appendectomy, complications of appendicitis, laparoscopic appendectomy

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Introduction

One of the most common causes of lower abdominal pain encountered in the emergency room is acute appendicitis. It is the most common cause of acute abdomen in young patients [1,2]. Lifetime incidence of acute appendicitis is 8.6 and 6.7% for men and women, respectively [3].

Complicated appendicitis includes perforated, gangrenous appendicitis, peri-appendicular mass, or abscess. Perforation is the most concerning complication of acute appendicitis and may lead to abscesses, peritonitis, bowel obstruction, fertility issues, and sepsis. The rate of perforation ranges from 16 to 40%, with a higher frequency occurring in younger age groups (40–57%) and in patients older than 50 years (55–70%) [4,5].

The mortality risk of acute nongangrenous acute appendicitis is less than 0.1%, but the risk rises to 0.6% in gangrenous acute appendicitis. Perforated acute appendicitis carries a higher mortality rate of ~5% [4].

Appendectomy for acute appendicitis is the standard treatment and a common emergency surgical procedure, either via open laparotomy or via laparoscopy. The indications for laparoscopic appendectomy remain controversial, despite the

publications of numerous randomized trials that compared open and laparoscopic appendectomy [6,7].

The World Society of Emergency Surgery (WSES) published guidelines for acute appendicitis that included recommendations regarding indications for laparoscopic appendectomy and choice of approach in 2016 [8]. These guidelines were subsequently updated in 2020 [9] and recommended laparoscopic appendectomy as the preferred approach over open appendectomy for both uncomplicated and complicated acute appendicitis where laparoscopic equipment and expertise are available.

Aim

This study aims to compare open and laparoscopic appendectomy in the management of complicated acute appendicitis regarding technical feasibility and operative time, postoperative complications such as wound infection, postoperative sepsis and ileus, start of oral intake, length of hospital stay, and return to normal activities.

Patients and methods

This was a prospective randomized controlled clinical trial that was performed from June 2021 to June 2022 at Ain Shams University Hospitals. The study included 50 patients with complicated acute appendicitis. Patients were divided into two groups according to the type of the procedure done for appendectomy, whether open or laparoscopic. Each group included 25 patients. Randomization was done using the closed envelope method.

The study included any patient coming to the ER with a provisional diagnosis of complicated appendicitis, that is, perforated or gangrenous appendicitis.

Patients with chronic medical illnesses such as diabetes mellitus, hypertension, chronic kidney disease, or with immunological disease; patients unfit for laparoscopic intervention such as patients with cardiac or pulmonary disease; and patients converted from laparoscopic to open procedure were excluded from the study.

Patients were fully informed about the risks and benefits of the two procedures. Informed consent was obtained from all patients. All patients provided consent to undergo conversion to open appendectomy if necessary.

All patients included in this study were subjected to detailed history, full clinical examination, laboratory tests, and pelviabdominal ultrasound.

Patients were randomly allocated into two groups:

(1) Group A had open appendectomy.
(2) Group B had complete laparoscopic appendectomy.

Prophylactic antibiotic in form of 2 g ceftriaxone was given preoperatively to all patients. Patients received either general or spinal anesthesia. All patients were operated by experienced surgeons with feasibility of all surgical equipment.

Surgical procedure

The patients were placed in the surgical position recommended for each technique; the patients lay supine with their arms extended in open appendectomies and placed to their side in the laparoscopic approach. The sterile surgical field extended from above the costal margin bilaterally to the pubic tubercle and extended laterally.

Group A: open appendectomy

A standard technique through grid iron incision was done. If the access to the appendix or its bases was difficult (Fig. 1), muscle cutting extension was done for better visualization and dissection. Appendectomy with peritoneal toilet was done with insertion of a tube drain. Closure in layers was done.

Figure 1

Perforated appendix in open appendectomy.

Group B: laparoscopic appendectomy

Access to the abdomen was achieved by a standard 3-port technique. Diagnostic laparoscopy was first done.

As a precautionary measure, further abdominal examination was achieved followed by peritoneal cleaning and drain placement (Figs 2 and 3).

If the visualization or dissection was difficult, converting to an open appendectomy was considered.

The two groups were compared in the following parameters: operative time from skin incision to skin closure, intraoperative complications, postoperative outcome including time needed to start oral intake, length of hospital stay and return to normal activities and postoperative complications as wound infection, and postoperative sepsis and ileus.

Statistical analysis

Descriptive statistics was done in terms of frequency and percentages for categorical variables. Mean±SD or median (interquartile range) was used for continuous variables. Statistical tests for comparing between groups were considered significant at a *P* value less than or equal to 0.05.

Figure 2

Perforated appendix with fecalith (in laparoscopic appendectomy).

Statistical package

The collected data were revised for accuracy and completeness, then coded and entered into a personal computer to be analyzed using IBM SPSS statistics for windows, Version 23.0. Armonk, NY: IBM Corp.

Ethical approval

This research was performed at the Department of General Surgery, Ain Shams University Hospitals. Ethical Committee approval and written, informed consent were obtained from all participants.

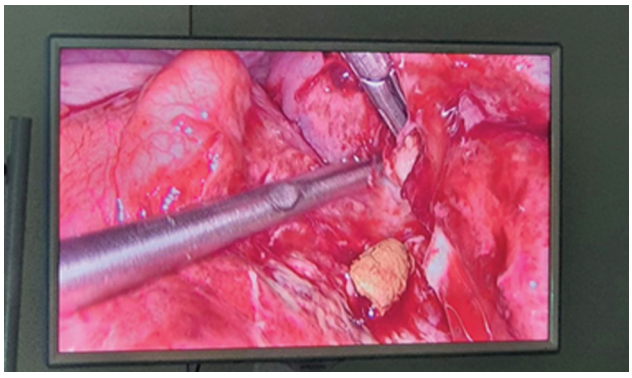
Results

This study was conducted on 50 patients with complicated acute appendicitis. Patients were divided into two groups: group A included 25 patients who underwent open appendectomy and group B included 25 patients who underwent laparoscopic appendectomy. Four more patients underwent laparoscopic appendectomy but they were converted to open, so we excluded them from the study.

Clinical and demographic features of the patients

The mean age of patients was 29.56 and 22.56 years in group A and group B, respectively. Overall, 20% were males and 30% were females in group A, and 28% were

Figure 3



Intra-abdominal fecalith after dissection of perforated appendix.

Table 1 Demographic data

	Open appendectomy [*n* (%)]	Laparoscopic appendectomy [*n* (%)]	*P* value	χ^2
Sex*				
Male	10 (20)	14 (28)	0.258	
Female	15 (30)	11 (22)	1.282	
Age (years)			*t* test	Significance
Range	15–55	15–35	2.307	
Mean±SD	29.56±14.024	22.56±5.788	0.025	

χ^2, χ^2 test. *t test=independent. *P* value more than 0.05 (no significant).

males and 22% were females in group B. These results are statistically insignificant (Table 1).

Clinical features of the patients on the time of admission

In the present study, all the patients (100%) came to the emergency department with right iliac fossa pain. Overall, 40% of the patients mentioned that the onset of symptoms was from 3 days, ranging from 2 to 7 days.

On physical examination, 74% of patients showed tachycardia, with mean pulse of 103 beat/min; 100% of patients were feverish, with mean temperature of 38.3°C; and abdominal examination showed that 100% of patients had tenderness and rebound tenderness on right iliac fossa.

Total leukocyte count was above 11 000 (100%) in all patients, ranging from 11 500 to 25 000, with a mean total leukocyte count of 15 800. C-reactive protein was positive in all patients (100%), ranging from 8 to 125, with a mean C-reactive protein of 44.5.

All patients underwent emergency pelviabdominal ultrasound, which showed both rim of free fluid in right iliac fossa with echogenic fat around in 23 (46%) patients, just echogenic fat in right iliac fossa 20 (40%) patients, and only rim of free fluid in right iliac fossa in seven (14%) patients.

Intraoperative data

In the present study, 19 (76%) patients in group A were operated under spinal anesthesia and six (24%) were operated under general anesthesia, whereas all patients in group B were operated under general anesthesia (100%). The mean operative time was significantly shorter in the open appendectomy group (77.8 ±1.555 min), when compared with the laparoscopic group (107.2±2.082 min) (Table 2).

Postoperative data

Regarding start of oral feeding, 44% of open group and 38% of laparoscopic group started sipping water on the first day, whereas 6% of open group and 12% of laparoscopic group started sipping on the second day. Mean duration of hospital stay after operation was 3.56±1.044 days in the open group and 4.08±1.187 days in the laparoscopic group. These results were statistically insignificant (Table 3).

Mean duration of return to normal activity was 12.6 ±2.93 days and 10.6±1.658 days in the open and laparoscopic groups, respectively. The result was statistically significant (Table 3).

Postoperative complications

There was a statistically significant difference between open and laparoscopic groups in postoperative complications as shown in Table 4. Overall, 26% of the study population was complicated with postoperative wound infection; 20% of them in the open group, and 6% in the laparoscopic group. Overall, 4% in the open group were complicated with postoperative ileus.

Discussion

Laparoscopic procedures are an efficient, safe, and increasingly popular approach in all surgeries [10]. The aim of this study was to compare the operative and postoperative outcomes of open and laparoscopic approaches in the management of acute appendicitis.

Table 2 Operative time

Operative time	Open appendectomy [*n* (%)]	Laparoscopic appendectomy [*n* (%)]	*P* value	χ^2
≤1 h 30 min	22 (44)	7 (14)	<0.001**	19.528
> 1 h 30 min and ≥2 h	3 (6)	10 (20)		
>2 h	0	8 (16)		

χ^2, χ^2 test. ***P* value was less than 0.001 (highly significant).

Table 3 Postoperative data

Start oral sips	Open appendectomy [*n* (%)]	Laparoscopic appendectomy [*n* (%)]	*P* value	χ^2
Day 1	22 (44)	19 (38)	0.269	1.220
Day 2	3 (6)	6 (12)		
Duration (days)	Open appendectomy	Laparoscopic appendectomy	*t* test*	*P* value
Hospital staying	3.56±1.04	4.08±1.19	1.644	0.107
Return to normal activity	12.6±2.93	10.6±1.66	2.97	0.005**

χ^2, χ^2 test. **t* test=independent. ***P* value was less than 0.05 (significant).

Table 4 Early postoperative complications

Postoperative complication	Open appendectomy [*n* (%)]	Laparoscopic. appendectom [*n* (%)]y	*P* value	χ^2
Wound infection	10 (20)	3 (6)	0.024*	5.094
Ileus	2 (4)	0	0.149	2.083
Sepsis	0	0		

χ^2, χ^2 test. **P* value was less than 0.05 (significant).

In the present study, the mean age of patients was 29.56±14.024 and 22.56±5.788 years in open and laparoscopic groups, respectively, with no significant difference between both groups. Shakya *et al.* [11] found the highest incidence of complicated appendicitis is observed among the age group of 11–20 years (26.44%) of followed by 21–30 years (18.97%).

The complicated appendicitis was found to be 38 (76%) perforated, 10 (20%) perforated with gangrenous appendix, and two (4%) formed appendicular mass. The same was seen in the study by Wagh and Joshi [12], which found that 61.6% of patients had perforated appendix, whereas 36.6% had gangrenous appendix. During laparoscopic appendectomy, we had better ability to do diagnostic laparoscopy for better assessment and visualization of the whole abdomen and pelvis and all areas of intra-abdominal collection.

In the current study, the operative time was significantly longer in the laparoscopic group, with mean time of 107.2±2.08 min than open group with mean time of 77.8±1.56 min, with *P* value of 0.001. The result comes in correspondence with the study by Yang *et al.* [13], which showed that the mean operative time for the laparoscopic appendectomy was longer (80 min) than in the open appendectomy (65 min), with a statistically significant difference (P=0.042). Mohamed and Mahran [14] revealed that laparoscopic appendectomy took longer time to perform, but Fukami *et al.* [15] documented no significant difference in the operating time between open and laparoscopic groups.

In this study, 26% of the study population was complicated with postoperative wound infection, with 10 (20%) cases in the open group and three (6%) cases in the laparoscopic group. The result was statistically significant (P=0.024). Shirazi *et al.* [16] reported that the rate of overall postoperative complications (LA: 15%, OA: 31.8%, P<0.0001) was significantly lower in laparoscopic appendectomy group. Taguchi *et al.* [17] reported no statistically significant difference between open and laparoscopic groups in the postoperative complications, including incisional or organ/space SSI and stump leakage.

In the present study, no cases (0%) in the laparoscopic group were unable to tolerate oral feeding, in comparison with two (4%) cases in the open group that developed ileus. Yet, this result was statistically insignificant. There were several explanations for the reduction of ileus following laparoscopic appendectomy, including decreased handling of the bowel during the procedure, patients had less postoperative opiate analgesics, which inhibited bowel movements in the postoperative period, and the earlier mobilization [18].

In the present study, no patient developed sepsis or intra-abdominal abscess. Horvath *et al.* [19] documented intra-abdominal abscess formation was more common in laparoscopic than open appendectomy. This can be explained on the basis that CO_2 insufflation in laparoscopic procedure may facilitate spreading of microorganisms in the peritoneal cavity, especially in perforated appendicitis.Although in this study there was no significant difference between open group and laparoscopic group in starting oral sips on the first day postoperative (88 and 76% of patients, respectively), 12% of patients started oral sips on the second day postoperative in the open group compared with 24% of patients in the laparoscopic group.

Mean duration of hospital stay after operation was 3.56 ±1.044 days in open group and 4.08±1.187 days in the laparoscopic group. The result was statistically insignificant. Oka *et al.* [20] documented that the length of hospital stay was 5.2 and 4.3 days in open and laparoscopic groups, respectively. This result was statistically insignificant. In this study, the mean duration of return to normal activity was 12.6±2.93 days and 10.6±1.658 days in open and laparoscopic groups, respectively. This result was statistically significant. Talha *et al.* [21] reported the mean time taken to resume routine work was 22.3±3.7 and 15.3 ±3.4 days for open and laparoscopic groups, respectively. In a study by Resutra and Gupta [22], the mean time taken to resume daily routine activities was 10.16±0.681 and 8.16±0.553 days in open and laparoscopic groups, respectively, with a statistically significant difference (P<0.05).

Conclusion

Laparoscopic appendectomy is safe and feasible surgical option for complicated acute appendicitis.

Despite having more operative time, it has less rate of postoperative complications with early return to normal activity.

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Nil.

Conflicts of interest
There are no conflicts of interest.

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