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# Laparoscopic versus Open Appendectomy in the Management of Complicated Appendicitis

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## Abstract

*Background: Complicated appendicitis (CA) refers to a condition when the appendix becomes gangrenous and has perforated, leading to different levels of peritonitis.*

*Aim: To compare laparoscopic and open appendectomy (OA) in managing cases of CA in Egyptian patients.*

*Methods: This prospective comparative work was performed on 50 individuals ranging in age between 24 and 60 years old, both genders, diagnosed with CA, high Leukocytic count, American Society of Anesthesiologists (ASA) I or II, delay time of diagnosis of appendicitis, pelvic collection diagnosed by ultrasound and Appendicular mass diagnosed by ultrasound or clinical after general anaesthesia and CA is defined as presence of perforated of gangrenous appendix with or without formation of abscesses. Individuals were categorized into two equal groups: the OA group, which underwent OA, and the laparoscopic appendectomy (LA) group, which underwent laparoscopic appendectomy.*

*Results: The incidence of superficial and deep SSI had been substantially higher in the OA group than in the LA group ( $P < 0.05$ ). Regarding operating time, length of hospital stays, visual analogue score (VAS) and satisfaction, a substantial variation existed among both groups, higher in the OA Group ( $P = 0.000$ ).*

*Conclusions: LA is a secure and effective surgical technique that offers significant therapeutic benefits compared to OA's results. Thus, we propose that LA be considered the preferred method for managing CA. Additional research is necessary to clarify its effectiveness in managing CA.*

**Keywords:** Laparoscopic; Appendectomy; Appendicitis

## 1. Introduction

Complicated appendicitis (CA) refers to a condition in which the appendix has undergone gangrene and perforation, leading to different levels of peritonitis.<sup>1</sup> It is linked to increased rates of illness, with wound infection rates of 20% compared to 5% in those without the condition (non-CA) and fatality rates of 5% compared to 0.8% in non-CA individuals.<sup>2</sup>

The McBurney method for open appendectomy (OA) has been considered the most reliable and widely accepted surgical treatment for removing the appendix.<sup>3</sup> Following its inception in clinical settings, laparoscopic appendectomy (LA) has shown its feasibility and safety, leading to its widespread

adoption globally. Multiple studies of discomfort and entry have shown the therapeutic benefits of LA, including shorter hospital stays, decreased risk of wound infections, earlier resumption of regular occupational activities, reduced postoperative ileus duration, less postoperative discomfort, and improved cosmetic outcomes.<sup>4</sup>

Nevertheless, the utilization of LA as the most reliable method for treating acute appendicitis is still a subject of discussion due to its longer duration of surgery, increased likelihood of postoperative intra-abdominal abscesses, and more significant expenses. Several studies have highlighted these concerns and have compared LA to OA. Although there have been inconsistent findings, several studies have shown the laparoscopic method to be preferable.<sup>5</sup>

Nevertheless, the precise advantages of laparoscopy as a diagnostic or therapeutic approach in treating complex or perforated appendicitis have yet to be determined. Contrary to expectations, laparoscopic surgery may provide clinical advantages in cases of ruptured appendicitis. Indeed, a shorter recovery period and the ability to avoid a lengthy surgical procedure would be beneficial, especially for patients with serious perforation who are already in critical condition.<sup>6</sup>

This work aimed to compare laparoscopic and OA techniques in managing cases of CA in Egyptian patients.

## 2. Patients and methods

This prospective comparative study was performed on 50 individuals.

2.1. Inclusion criteria were age between 24 and 60 years old, both sexes, diagnosed with CA, high leukocytic count, American Society of Anesthesiologists (ASA) class I or II, delay time of diagnosis of appendicitis, pelvic collection diagnosed by ultrasound and Appendicular mass diagnosed by ultrasound or clinical after general anesthesia and CA is characterized by the presence of a perforated or gangrenous appendix, with or without the development of an abscess.

The work was done following approval from the Ethics Committee at Al-Azhar University, Cairo, Egypt. The patients provided well-informed written consent.

2.2. Exclusion criteria were active infection, coagulopathy, malignancy, generalized peritonitis, and Patients who had a prior medical history of open abdominal or pelvic surgeries, as well as concurrent removal of a portion of the bowel.

Patients were categorized into two groups equally: Group (1), who received OA, and Group (2), who received LA.

All patients underwent a series of assessments, including obtaining medical history, conducting a clinical examination, performing laboratory tests [such as a complete blood count (CBC), liver function tests (including alanine aminotransferase (ALT), aspartate aminotransferase (AST), serum bilirubin, serum albumin, serum gamma-glutamic transferase (GGT), prothrombin time (PT), and international normalized ratio (INR)), and conducting kidney function tests (including serum creatinine, blood urea, and urine analysis). Additionally, radiological studies were conducted utilizing a transabdominal ultrasound with a low-frequency probe and a large convex footprint.

2.3. Laparoscopic appendectomy: The abdomen was accessed by creating a 12 mm incision below the umbilicus. Either the Hasson

procedure or a Veress needle was used to introduce carbon dioxide gas into the peritoneal cavity. Subsequently, a laparoscope with a 5-mm angled tip was introduced.

Subsequently, a 5 mm port was inserted in the middle of the midline, just above the pubic bone, and another 5 mm port was inserted laterally in the left lower quadrant. The laparoscope was introduced using this lateral opening. The surgeon utilized the midline ports for the surgical procedure. The first trocar for the optical instrument, a 10 mm lens, was inserted near the umbilicus. Subsequently, two trocars with a diameter of 5 mm were used and located in the lower right quadrant, somewhat above the pubic area. They were located in the left iliac fossa. The first trocar functioned as the pathway for gripping the appendix.

The second trocar was positioned to accommodate the operating equipment for the right-handed surgeon, assuming a typical anatomical location for the appendix. Nevertheless, it is essential to consider the placement adjustments of the 5 mm trocar in cases of anatomical differences, such as the subhepatic appendix. Under these conditions, it was advised to position the trocar similarly to a cholecystectomy. Subsequently, an examination of the abdomen was conducted in order to exclude the possibility of additional illnesses. Next, the focus shifted to the lower right quadrant. To enhance visibility, the patient may be placed in a steep Trendelenburg position with the right side elevated and the head lowered. Subsequently, both the omentum and the small bowel have been shifted upwards. The fold of Treves, also known as antimesenteric fat, may serve as a reliable marker for identifying the terminal ileum.

The cecum was located by tracing the path of the terminal ileum. Typically, the appendix may be discovered by tracing the taeniae of the cecum. Nevertheless, if encountering a retrocecal appendix, it could be imperative to mobilize the cecum and ascending colon by severing their lateral retroperitoneal attachments. When the individual is positioned correctly, the appendix may be readily detected, and the dissections should be finished. Alternatively, the base of the appendix should be examined immediately beyond the ileocecal junction by tracing the merging of the three colonic taeniae. In order to achieve this objective, the surgeon should retract the farthest part of the ileal loop with their right-hand tool, while the left-hand instrument ensures the best possible exposure of the cecum.

In individuals with a sub-serosal appendix, the recommended method was to dissect the visceral peritoneum fully. After the appendix was found, it should be kept tightly stretched. There is no

particular preference for holding the appendix either by its tip or body. When dealing with phlegmon or gangrene in the appendix, it is crucial to use extreme care. It is advisable to use meso-appendix directly in these cases. The meso-appendix should be dissected using bipolar coagulation, starting at the tip and moving towards the base. It is essential to mention that monopolar coagulation was discouraged due to the potential danger of burning the cecum or terminal ileum.

A visual analogue score (VAS) assessed postoperative satisfaction and pain.

2.4.VAS: The pain intensity score was assessed by individuals who indicated a mark on a scale ranging from 0 to 10 cm, with scores between 0 and 4 cm indicating minor discomfort. The discomfort is moderate, 5-7 cm, and severe, 8-10 cm. Comparison was made between both groups in terms of operating time, occurrence of surgical site infections (SSI), creation of intraabdominal abscesses (IAA), development of postoperative ileus (PI) and appendiceal stump insufficiency (ASI), as well as duration of hospital stay. The Centers for Disease Control and Prevention (CDC) classified SSI into two categories: superficial and deep incisional SSI.

### 2.5. Statistical analysis

The statistical analysis was conducted using SPSS v26 software (IBM et al., USA). The quantitative parameters were expressed as the mean and standard deviation (SD) for comparing both groups using an unpaired Student's t-test. When appropriate, the qualitative parameters were shown as frequencies and percentages (%) and assessed using either the Chi-square test or Fisher's exact test. A two-tailed P value < 0.05 was considered statistically significant.

## 3. Results

Table 1. Demographic data of studied groups

		OA GROUP (N = 25)	LA GROUP (N = 25)	P VALUE
AGE (YEARS)		42.8 ± 11.5	43.4 ± 11.3	0.833
SEX	Male	14 (56%)	15 (60%)	0.774
	Female	11 (44%)	10 (40%)	
BMI (KG/M <sup>2</sup> )		32.4 ± 4.5	31.3 ± 4.9	0.409
ASA GRADE	Grade I	13 (52%)	15 (60%)	0.395
	Grade II	12 (48%)	10 (40%)	

Data are presented as mean ± SD or frequency (%). \*Significant p value < 0.05, LA: laparoscopic Appendectomy, OA: Open Appendectomy, BMI:

Body mass index, ASA: American Society of Anesthesiologists.

Regarding age, sex, BMI and ASA grade, no substantial variation was existed among between studied groups. Table 1

Table 2. Surgical outcomes of studied groups

	OA GROUP (N = 25)	LA GROUP (N = 25)	P
SURGICAL OUTCOMES			
OPERATING TIME (MIN)	67.7 ± 5.3	54.5 ± 6.3	0.000*
LENGTH OF HOSPITAL STAY (DAYS)	7.2 ± 1.6	5.6 ± 0.9	0.000*

Data are presented as mean ± SD. \*Significant p value < 0.05, LA: laparoscopic Appendectomy, OA: Open Appendectomy.

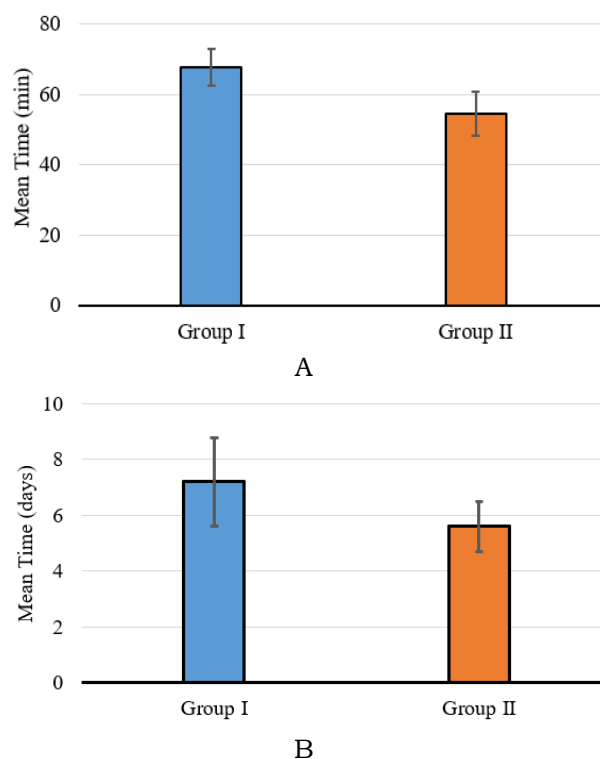


Figure 1. A) Operating Time, B) Length of Hospital Stay

Regarding operating time and duration of hospital stays, a substantial variation was existed among groups (P = 0.000). Table 2, Figure 1

Regarding VAS and satisfaction, a substantial variation was existed among groups (P = 0.000). Table 3

Table 3. Reported outcomes of studied groups

	OA GROUP (N = 25)	LA GROUP (N = 25)	P
REPORTED OUTCOMES			
VAS FOR PAIN	5.7 ± 1.5	3.6 ± 1.1	0.000*
SATISFACTION	1.7 ± 0.7	3.8 ± 0.9	0.000*

Data are presented as mean ± SD. \*Significant

p value<0.05, LA: laparoscopic Appendectomy, OA: Open Appendectomy, VAS: visual analogue scale.

The incidences of superficial and deep SSI were substantially greater in the OA group compared to the LA group ( $P < 0.05$ ). On the other hand, no significant differences were found between both groups in terms of intra-abdominal abscess, postoperative ileus, and appendectomy stump insufficiency ( $P > 0.05$ ). [Table 4](#)

Table 4: Postoperative complications of studied groups

	OA GROUP (N = 25)	LA GROUP (N = 25)	P
SUPERFICIAL SSI	6(24%)	1(4%)	0.042*
DEEP SSI	4(16%)	0(0%)	0.037*
INTRA-ABDOMINAL ABSCESS	5(20%)	1(4%)	0.082
POSTOPERATIVE ILEUS	2(8%)	1(4%)	0.552
APPENDECTOMY STUMP INSUFFICIENCY	0(0%)	2(8%)	0.149

Data are presented as frequency (%). \*Significant p value<0.05, LA: laparoscopic Appendectomy, OA: Open Appendectomy, SSI: Surgical-Site Infection.

#### 4. Discussion

Acute appendicitis is a frequent source of acute abdominal pain, occurring in around 7-9% of individuals during their lifetime. Consequently, appendectomy is among the most often conducted surgical operations. McBurney initially defined the open technique of appendectomy. <sup>7</sup>

In the current study, the mean operating time was  $67.7 \pm 5.3$  min and  $54.5 \pm 6.3$  min in groups I and II, respectively. A statistically substantial variation existed among groups regarding operating time (Independent sample t-test,  $P = 0.000$ ). Our results supported Takami et al. <sup>8</sup>, who stated that a substantial variation in operating time was expressed among the studied groups. Also, the same results were shown in Frazee et al. <sup>9</sup>. Horvath et al. <sup>10</sup> reported that LA for CA is associated with a significantly shorter operative time when compared with patients who had OA.

Our study showed that the mean duration of hospitalization was  $7.2 \pm 1.6$  days and  $5.6 \pm 0.9$  days in groups I and II, respectively. A statistically substantial variation was found among groups regarding length of hospital stay ( $P = 0.000$ ). Multiple studies demonstrated that the primary advantages of LA for CA involve reduced duration of hospital stay.<sup>11</sup> Our results supported Takami et al. <sup>8</sup>, who stated that a substantial variation existed among the studied groups regarding length of hospital stay. Also, Horvath et al. <sup>10</sup> reported that LA is associated with reduced length of hospitalization when

contrasted with individuals with OA.

Our study showed the mean VAS for pain was  $5.7 \pm 1.5$  and  $3.6 \pm 1.1$  in groups I and II, correspondingly. A statistically substantial variation existed among groups regarding VAS for pain ( $P = 0.000$ ). Moreover, the mean satisfaction (Likert-based) score was  $1.7 \pm 0.7$  and  $3.8 \pm 0.9$  in groups I and II, respectively. A statistically substantial variation existed among groups regarding satisfaction scores ( $P = 0.000$ ). Minutolo et al.<sup>12</sup> reported that LA was the preferred approach in acute appendicitis. Also, Horvath et al.<sup>10</sup> reported that statistically substantial variation existed among groups regarding satisfaction scores.

Our study showed that superficial SSI was reported in 6(24%) patients in the OA group and 1 (4%) in the LA group. Deep SSI was only reported in 4(16%) patients in the OA group. Intra-abdominal abscess was reported in 5 (20%) individuals in the OA group and 1(4%) patient in the LA group. Postoperative ileus was reported in two (8%) patients in group OA and 1 (4%) patient in the LA group. Insufficiency of the appendectomy stump was reported only in 2 (8%) patients in the LA group. Moreover, the incidences of superficial and deep SSI were significantly higher in the OA group compared to the LA group ( $P < .05$ ). On the other hand, no significant differences were found between the two groups in terms of intra-abdominal abscess, postoperative ileus, or appendectomy stump insufficiency ( $P > 0.05$ ). In agreement with a recent meta-analysis, Sauerland et al.<sup>13</sup> documented a decreased incidence of postoperative consequences, particularly regarding SSI, following LA. Our findings corroborated the findings of Takami et al. <sup>8</sup>, indicating a significant difference in wound infections across the groups under study.

Postoperative complications were seen in 4 individuals (2.9%) in the LA group and 12 individuals (13.2%) in the OA group. There was a statistically substantial distinction in favour of the LA group ( $p = 0.0061$ ). Nevertheless, there was no substantial disparity among both groups in terms of the occurrence of intra-abdominal abscess ( $p = 0.563$ ), prolonged ileus ( $p = 0.303$ ), pleurisy ( $p = 0.395$ ), and urinary tract infection ( $p = 1.000$ ). Furthermore, Horvath et al. <sup>10</sup> observed that SSI was only seen after OA, with 38 patients affected compared to none in other procedures. There was a substantial increase in intraabdominal abscess development following LA, with 10 individuals experiencing this compared to just two patients in the control group ( $p = 0.002$ ). No statistically significant findings existed regarding the incidence of postoperative ileus ( $p = 0.261$ ) or appendiceal

stump insufficiencies ( $p = 0.076$ ).

There is a consistent worry about the increased likelihood of postoperative intraabdominal collection for severe appendicitis, and there have been reports on the high occurrence of collections following LA.<sup>14</sup>

Multiple meta-analyses of randomized controlled trials (RCTs) conducted in the last years<sup>13,15</sup> have shown a heightened likelihood of intra-abdominal abscesses following LA. There is a suggestion that this complication may be primarily linked to an incorrect laparoscopic approach, including a forceful manipulation of an infected appendix or an excessive administration of irrigation fluids, resulting in substantial contamination of the peritoneal cavity.<sup>16</sup> Nevertheless, the latest meta-analysis of randomized controlled trials was released.<sup>16</sup>

The incidence of intra-abdominal abscesses was very low (1.3%) in our research, and no statistically significant disparity existed among both treatments. The observed results are likely attributed to eliminating individuals displaying clinical indications of a ruptured appendix from our research, as well as the exceptional laparoscopic expertise of the surgeons performing the LA. Consistent with previous research, Yeh et al.<sup>17</sup> show that LA is a viable and secure method. Furthermore, Horvath et al.<sup>10</sup> said that LA is a secure and practical method for managing CA.

The limitations of our findings were attributed to the limited sample size and the fact that it was single-centre research. Therefore, we suggest that future research include meticulously planned RCTs or extensive comparative observational studies. Ensure the inclusion of a representative sample of individuals with comparable characteristics such as age, sex, and illness severity—collecting data utilizing standardized instruments and procedures at consistent intervals after a surgical procedure. In order to get precise evaluations of long-term results, studies must have an extended follow-up duration.

#### 4. Conclusion

LA is a secure and effective surgical technique that offers significant therapeutic benefits compared to OA results. Thus, we recommend using laparoscopic appendectomy as a method for treating CA. Additional research is necessary to clarify LA's effectiveness in managing CA.

#### Disclosure

The authors have no financial interest to declare in relation to the content of this article.

#### Authorship

All authors have a substantial contribution to the article

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There are no conflicts of interest.

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