Comparison between laparoscopic versus open appendectomy in morbid obese patients

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Purpose
To evaluate the laparoscopic approach advantages for the management of acute appendicitis in morbidly obese patients.
Methods
A prospective study included all morbidly obese patients who had presented to the emergency department at Sohag University Hospitals and were diagnosed with acute appendicitis between the 1st of June 2022 and the 31st of January 2023. All those patients were invited to participate in the research by randomization. The authors informed patients and their first-degree relatives about both techniques, signed a consent form for participation in the study. The authors categorized them into two groups; laparoscopic approach (group I) and open approach (group II). Comparisons were based on operative time, intraoperative complications, length of hospital stay, postoperative complications, and time until return to normal daily activities.
Results
The study enrolled 64 patients: 33 had a laparoscopic appendectomy, and 31 had an open appendectomy. The groups were similar in terms of clinicopathologic characteristics. The operating time was significantly shorter for Group I patients than Group II (Group I, 49.09±16.21 min vs. Group II, 68.03±15.78 min; *P* value less than 0.05). Regarding the length of hospital stay, twenty-six patients (78.8%) were discharged within the 1st 24 h in the laparoscopic group versus 17 patients (54.8%) in the open group (*P* value 0.041). The time until return to the routine daily work was significantly shorter in the laparoscopic group (11.27±2.6 days) than in the open group (17.23±4.8 days) (*P* value less 0.05). Four postoperative complications were reported in the study population: wound complications (infection, seroma formation), residual abdominal abscess, paralytic ileus, and thromboembolic complications (Deep venous thrombosis and pulmonary embolism). Group II had a statistically significant higher complication rate (32.3%) than Group I (9.09%) (*P* value 0.007).
Conclusion
Laparoscopic appendectomy had superior clinical outcomes than an open appendectomy in morbidly obese patients. In addition to minimal invasiveness and better cosmetic results, it has a great advantage as a diagnostic and therapeutic tool in morbidly obese patients with suspected appendicitis. It is also a safe and feasible approach with a low rate of complications with a well-trained expert surgeon.

Keywords:
Laparoscopic appendectomy, morbid obesity, open appendectomy

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Introduction

Appendicitis is one of the most common causes of acute abdomen worldwide [1]. Obesity is an increasing pandemic, and the prevalence of obesity has tripled in the last four decades [2]. Consequently, the frequency of appendectomy in obese patients will increase. Appendectomy by open or laparoscopic approach is the most frequent procedure in the daily emergency surgical lists worldwide. McBurney described the classical open appendectomy at the end of the 19th century [3]. Kurt Semm performed the first laparoscopic appendectomy in 1983, and since this time, it has largely replaced open surgery in both simple or complicated acute appendicitis with variable debates [4].

In general, abdominal surgeries using the open technique in morbidly obese patients need more extensive wounds and cause more postoperative pain. Those patients are more liable for pulmonary and thromboembolic complications than the normal-

weight population, especially who had laparotomies [5]. Although laparoscopic appendectomy had the disadvantage of longer operative time compared to the open technique in normal-weight people, in the morbidly obese population, it had many advantages which overcome the burden of longer operative time. Laparoscopic appendectomy also has many benefits compared to the open technique, especially in diagnostic and cosmetic aspects [6]. This study will compare the laparoscopic and open appendectomy in morbidly obese patients admitted to an emergency department in a tertiary center.

Aim of the work

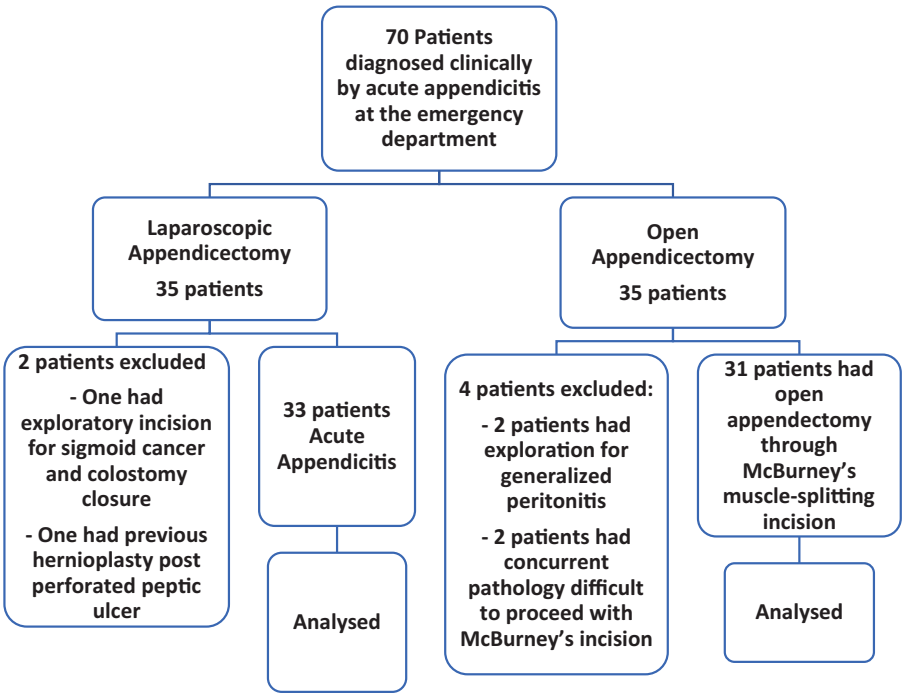
The study compares the laparoscopic approach (group I) and open technique (Group II) in appendectomy operations to manage morbidly obese patients who presented with simple or complicated appendicitis. The outcomes include operative time, length of hospital stay, and early postoperative complications.

Patients and methods

A prospective study included all morbidly obese patients who had presented to the emergency department at Sohag University Hospitals and were diagnosed with acute appendicitis between the 1st of June 2022 and the 31st of January 2023. All those patients were invited to participate in the research by randomization. The authors informed patients and their first-degree relatives about both techniques, signed a consent form for participation in the study. The authors categorized them into two groups; laparoscopic approach (group I) and open approach (group II). All group I patients consented to the probability of conversion to open technique if the operative circumstances and safety of the patient needed that. All patients agreed to use the photos and operative videos in the research with no identification mark to their personalities. Excluded patients were demonstrated at the flow diagram of the study (Fig. 1). All the patients received Prophylactic preoperative antibiotics.

All the patients in group II were achieved through a McBurney's muscle-splitting incision and cutting of the muscle if there was an intraoperative difficulty. For group I, laparoscopic appendectomy was performed using three ports (umbilical, 10 mm (right working hand); suprapubic, 5 mm (left working hand); left iliac fossa, 10 mm (camera). The appendicular artery was divided after closure using an ultrasonic device or hemostatic clips or coagulated by bipolar diathermy. The authors close the appendicular base with a Liga clip or three-loop ligatures, then divide and remove through the 10-mm umbilical port. The appendix base was invaginated in both procedures by a purse string suture (Authors' preference, it may decrease adhesions of the omentum to the appendicular stump or to

Figure 1



Flow diagram of the study.

support stump closure in the case of the perforated appendix at the base). Sending the resected appendix for histopathologic examination is not a routine step (only in old patients above 50 years old, or in suspicious appendicular masses). Tables 1–3 show the pre-, intra-, and post-operative data. The operative time was calculated from the incision's beginning to the wound's closure. Time of discharge was divided into three categories; within 24 h, within 24–48 h, and more than 48 h postoperatively. The authors follow the patients until they return to regular daily activity and work through the post-operative outpatient clinic visit or by phone.

Statistical analysis

Data were managed and analyzed using SPSS version 22 for Windows (SPSS Inc., Chicago, IL, USA). Categorical data were expressed as percentages, and continuous data were presented as mean ± standard deviation. The data were analyzed using Student's *t*-test or χ^2 tests. Statistical significance is determined to be a probability value less than 0.05.

Ethical considerations

The authors followed all regulations of the ethical committee at the Faculty of Medicine at Sohag University. Each patient had a private file with a non-disclosure policy at data presentation where all presented data did not contain any personal information specifying the identity of any of the patients. All the patients will have a clear verbal and written description of the study. Only those who will be consented to participate after descriptions (informed consent) were enrolled in the study. The participants have the right to withdraw from the study without giving any reasons.

Table 1 Patients' characteristics

	Laparoscopic appendectomy (33 patients)	Open appendectomy (31 patients)	*P* value
Mean age (years)	34.9±10.7 (19-52)	36.28	0.840
Sex:			
Male	13 (39.4%)	12 (38.7%)	0.955
Female	20 (60.6%)	19 (61.3%)	
Mean BMI	45.9±3.7 (40–53)	46.26 (41–52)	0.640
Comorbidities	12	13	0.920
Diabetes	8	7	
Hypertension	2	3	
OSAS	1	1	
Cardiopulmonary accident	0	1	
Cerebrovascular accident	1	1	
WBCs	11.36	12.9	0.163
Ultrasound finding			0.894
Acute appendicitis	24 (72.7%)	23 (74.2%)	
Complicated appendicitis (early mass – abscess).	9 (27.3%)	8 (25.8%)	

Table 2 Operative and postoperative data

	Laparoscopic appendectomy	Open appendectomy	*P* value
Operative time (min)	49.09±16.21	68.03±15.78	0.000
Intraoperative complications	2 casesSerosal tears Mesenteric tear and controlled bleeding.	4 cases2 Serosal tears Bleeding from friable mesentery	0.348
Accidental concurrent findings.	6 casesAbnormally adherent right ovary to anterior abdominal wall causing pain the right lower abdomen with any movement. Right and left ovarian haemorrhagic cyst. Infantile uterus (cause of sterility) Mesenteric lymphadenopathy with suspicions mass (diagnosed lymphoma). Right haemorrhagic ovarian cyst. Tubo-ovarian abscess	1 caseMikel's diverticulum.	0.044
Length of Hospital Stay (Discharge Day)			
within 24 h	26 (78.8%)	17 (54.8%)	0.041
24-48 h	4 (12.1%)	8 (25.8%)	
More than 48 h.	3 (9.1%)	6 (19.4%)	
Return to normal work (days ± Standard deviation)	11.27±2.6	17.23±4.8	0.000

Results

Sixty-four patients enrolled in this study: 33 had a laparoscopic appendectomy (group I), and 31 had an open appendectomy (group II). None of the group II patients had the procedure converted to open surgery. The groups did not significantly differ in mean Age, BMI, white blood cell counts, and female ratio (*P* value 0.05). In group, I, 24 patients (72.7%) were acute appendicitis, and 9 (27.3%) had complicated appendicitis (Appendicular mass and abscess formation). In group II, 23 patients (74.2%) had acute appendicitis, and 8 (25.8.8%) were complicated appendicitis (localized appendicular abscess). None of these percentages had statistically significant differences between both groups (Table 1).

The operating time was shorter for group I patients (49.09±16.21 min) than for group II patients (68.03 ±15.78 min), and the difference was statistically significant (*P* value less than 0.05). Unexpected intraoperative concurrent findings other than appendicitis were more evident in group I. Six cases had pathology other than appendicitis in the laparoscopic group: hemorrhagic ovarian cyst, infantile uterus, lymphoma, and concomitant tubo-ovarian abscess. On the other hand, one case in the conventional group was inflamed Mikel's diverticulum. Regarding the length of hospital stay, twenty-six patients (78.8%) were discharged within the 1st 24 h in the laparoscopic group versus 17 patients (54.8%) in the open group (*P* value 0.041). The time until return to the routine daily work was significantly shorter in the laparoscopic group (11.27±2.6 days) than in the open group (17.23±4.8 days) (*P*-value less 0.05) (Table 2).

Four postoperative complications were reported in the study population: wound complications (infection, seroma formation), residual abdominal abscess, paralytic ileus, and thromboembolic complications (Deep venous thrombosis and pulmonary embolism (Table 3). Group II had a higher complication rate (32.3%) than Group I (9.09%) (*P* value less than 0.05). Post-operative wound complications were more common after open appendectomy (6 patients, 19.4%) than laparoscopic appendectomy (2 patients, 6.06%). Two patients had a residual abdominal abscess in group II (6.5%) and none in group I. Post-operative paralytic ileus occurred in three patients with open appendectomy, but no patient had developed ileus in the laparoscopic group.

Discussion

Appendicitis is the most common abdominal condition requiring urgent intervention. Since 1975, the prevalence of obesity in the world has tripled. In 2016, over 1.9 billion adults, 18 years and older, were overweight. Of these, over 650 million were obese [7]. Given that obesity prevalence is increasing, the frequency of appendectomy in an obese patient also increases. Conventional surgeries in obese populations have shown several problems, especially regarding postoperative wounds and cardiopulmonary complications. Laparoscopy is approved now as a valuable minimal-invasive technique for diagnostic and therapeutic purposes in emergencies and elective cases [8–10]. However, laparoscopy may need more operative time and general anesthesia; it has many advantages, such as less postoperative pain, minimal scar, shorter hospital stay, faster recovery, and a decreased metabolic response in surgical patients. The benefits of laparoscopic surgery in obese patients documented for cholecystectomy for nearly 30 years [11]. In the case of appendectomy, there is considerable debate regarding the advantages of Laparoscopic appendectomy versus the conventional open approach. In thin patients, open appendectomy involves a small incision and shorter operative time provided that there are no abnormally positioned appendices and a skilled surgeon. Conventional surgeries in obese patients usually need more extensive wounds and cause more post-operative pain, wound complications and pulmonary complications than in the normal-weight population [12]. The retro-caecal appendix also may require larger wounds for proper dissection, especially for obese patients. Practically, all appendicular anatomic variations can be dominated laparoscopically by surgeons experienced in laparoscopic surgical techniques using small holes.

Table 3 Postoperative complications

Complication	Laparoscopic appendectomy	Open appendectomy	P value
Wound complications	2 (infection umbilical port incision	6 (4 wound theroma ± infection, 2 wound infections	
Residual abscess	0	2 (Residual abscess + ileus)	
Paralytic ileus ONLY	1	1	
Thromboembolismproblems	0	1	
Total	3 (9.09%)	10 (32.3%)	0.007

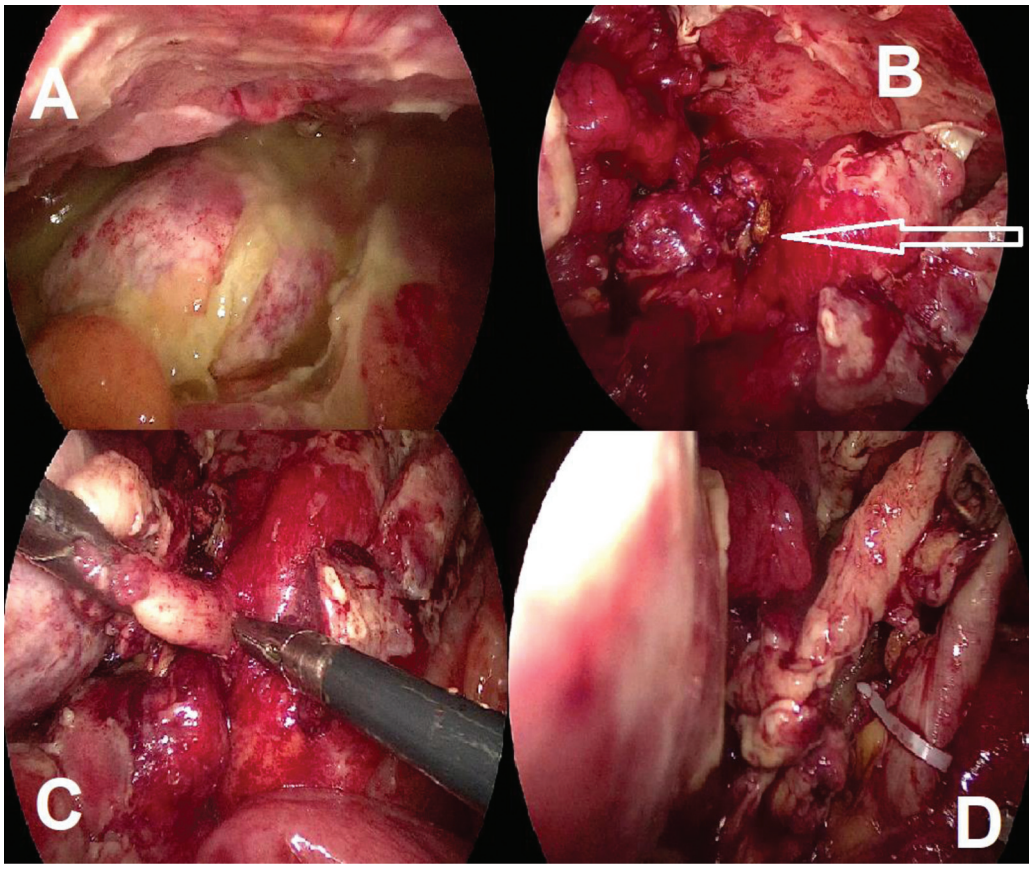
Laparoscopy has a significant advantage as a diagnostic and therapeutic tool in suspicious appendicitis patients. Gynaecologic pathologic conditions frequently masquerade as appendicitis. Laparoscopy is ideal for managing patients with reproductive system problems and presumed appendicitis. Tubo-ovarian problems such as complicated ectopic pregnancy, hemorrhagic ovarian cyst, ovarian abscess, and ovarian torsion; are frequent gynecologic emergency conditions [13]. In the current study, laparoscopy was diagnostic and therapeutic in 6 cases with concurrent disorders and presumed appendicitis. One case complained of recurrent right lower abdominal pain triggered by truncal movement. Laparoscopy revealed a massive adherent right ovary to the anterior abdominal wall, which induces pain by ovarian traction with every truncal move (Fig. 2). Another case was a female patient who presented with a clinical picture of appendicitis. She was complaining of infertility and hypomenorrhea. During a laparoscopic appendectomy, an infantile uterus (with nobody at all) was the cause of the sterility in this patient. The third case, 19 years male, presented a picture of appendicitis and mesenteric lymphadenopathy. A suspicious 2*1.5 cm ceacal mass near the base of the appendix was discovered during the exploration of the abdomen and diagnosed by mesenteric lymph node biopsy as lymphoma. The remaining cases were perforated appendix with tubo-ovarian abscess and generalized peritonitis (Fig. 3), a right concurrent ovarian haemorrhagic cyst, and one case had a bilateral ovarian cyst. Proper management of the current pathologies would be complex in obese patients if they operated through limited McBurney's incision. Regarding the open appendectomy cases, we have one patient with a normal appendix, so the operator searched for other causes; Meckel's diverticulitis was the cause of abdominal pain. From the previous, the exploratory function was more evident in the laparoscopic approach than the open one because of the limited operative field in the latter.

Long operative time was a primary concern influencing the widespread use of Laparoscopic appendectomy. Many studies suggested a significant increase in operative times for laparoscopic appendectomy [14,15]. Clarke *et al.* and Enochsson *et al.* found that overweight patients who underwent laparoscopic appendectomy had longer operating and anaesthesia times than their open procedures [14,15]. Mason *et al.* and Corneille *et al.* reported that laparoscopic appendectomy in obese patients had significantly shorter operative time than open appendectomy [16,17]. In the current study, although there was no significant difference in the complicated cases, the operative time was significantly longer in the open appendectomy than in the laparoscopic group. Many factors may affect the operative time in laparoscopic appendectomy, such as surgeon experience, previous abdominal operations, and the case's complexity. Jeon *et al.* concluded that overweight, high C-reactive protein, symptoms of >3 days, appendix diameter of >10 mm, and appendicular abscess were independent predictive factors of prolonged operative time [18]. Authors in the current study found a positive correlation between the longer operative time and preoperative white blood cells, appendicular complications in the preoperative ultrasound, and intraoperative complications (Table 4). Age, Sex, BMI, previous operations, and presence of concurrent pathology were not correlated to prolonged operative time in this study. The operative time in the group I patients was significantly shorter than in those who underwent

Figure 2

Adherent right ovary at the anterior abdominal pain.

Figure 3



Perforated appendix associated with ovarian abscess: a) massive peritonitis b) Appendicular Fecolith appeared during dissection of the perforated appendix c) dissection of the base d) Clipping of the appendicular base.

Table 4 Correlation between variables and operative time

	Laparoscopic appendectomy		Open appendectomy	
Variable	Person correlation	Significance	Person correlation	Significance
Sex	–0.046	0.800	0.087	0.642
Age	0.294	0.090	–0.050	0.790
BMI	0.278	0.130	0.020	0.913
Comorbidities	0.108	0.550	–0106	0.572
Previous operations	0.266	0.154	0.138	0.426
White blood cells	0.719	0.000	496	0.005
Ultrasound findings	0.845	0.000	0.801	0.000
Intraoperative complications	0.611	0.000	0.458	0.01
Concurrent pathology	0.312	0.188	.061	0.735

open appendectomy. This would be explained by performing the procedures via surgeons with more than nine years of experience in laparoscopic surgery.

Patients who recover quickly in the postoperative period are usually discharged from the hospital and return to work earlier. Regarding postoperative recovery and hospital stay, many researchers found that an early return to daily activity and work is an obvious advantage of Laparoscopic appendectomy [14–17]. During the laparoscopic approach, trocar incisions cause minimal trauma to the abdominal wall and are less painful in the postoperative period [19]. Also, there is minimal manipulation of the cecum and ileum, therefore less incidence of paralytic ileus and faster resumption of a regular diet [20]. Valera *et al.* performed laparoscopic appendectomy for acute and perforated appendicitis with a shorter length of stay and lower morbidity and costs [21]. In the current study, the length of hospital stay was shorter in group I

than in group II. High white blood counts, positive ultrasonic findings of complicated appendicitis, longer operative time, and occurrence of intraoperative complications were positively correlated variables with longer hospital stays (Table 5). Although difficult appendicitis percentages in both groups were comparable (27.3% in group I and 25.8% in group II), faster recovery and shorter hospital stays were in group I. In group I, 78.8% of the patients had been discharged within the first 24 h versus 54.8% in group II. Also, both groups significantly differed regarding the return to regular daily routine work (Table 2).

In obese patients, laparoscopic appendectomy had superior clinical outcomes compared with open appendectomy after accounting for preoperative risk factors [16]. In the current study, the complication rate (9.09%) was significantly lower in group I patients compared to those who underwent open appendectomy (32.3%) despite no significant difference between both groups in demographic data, comorbidities or the number of complicated appendicitis and all patients operated by the same team. Similar results have been reported in many studies on patients with morbid obesity [16,21]. Mason *et al.* analyzed 13330 obese patients who underwent appendectomy (78% laparoscopic and 22% open) and found that Laparoscopic appendectomy was associated with a 57% reduction in overall morbidity [16]. Masoomi *et al.* also reported a lower complication rate in obese patients who operated by laparoscopic approach [22].

Obesity is a well-known risk factor for wound infection, so the wound infection rate is low in a minimally invasive approach because of more minor wounds [23]. The open approach in morbidly obese patients has a greater chance of wound complications such as infection, hematoma, seroma formation, and burst abdomen. A meta-analysis by Woodham *et al.* established the laparoscopic appendicectomy as the preferred technique for the obese population, with 50% lower morbidity and a 66% reduction in wound infections [6]. The following causes could explain the higher rate of wound complications in the open approach: First, the direct extraction of the inflamed appendix through the wound but via a bag or the trocar in laparoscopic procedures. Second, the length of port-site wounds in the laparoscopic approach is smaller than the large extended wounds needed in the open approach. Third, large incisions in obese patients are more liable for post-operative fat liquefaction. Many factors contribute to the increasing incidence of fat liquefaction in post-operative wounds in the obese population: a) Thick abdominal subcutaneous fat. b) Unnecessary and overuse of electrocautery in surgery (thermal coagulation and thrombosis in adipose tissue capillaries cause aseptic necrosis of fat tissue and more exudation). c) Prolonged exposure of the incision and mechanical irritation (such as compression by retractors and forceps clipping) [24].

Post appendectomy abdominal abscess and ileus are a big concern in the literature. The incidence of Intra-abdominal abscess in complicated appendicitis is 3% to 25% [25,26]. Sauerland *et al.* reviewed 67 studies comparing laparoscopic and open appendectomy and reported an increased risk of abdominal abscess in the former [27]. On the other hand, Asarias *et al.* said no significant difference in the incidence of abscess formation in both approaches. The incidence was higher in patients with complications than uncomplicated appendicitis [28]. Nataraja *et al.* also concluded that the main factor for the abscess development was the condition of the appendix rather than the technique of its extraction [29]. In the current study, despite no significant difference between the two groups regarding the number of complicated cases, the abscess formation rate was

Table 5 Correlation between variables and length of hospital stay

	Laparoscopic appendectomy		Open appendectomy	
Variable	Person correlation	Significance	Person correlation	Significance
Sex	–0.123	0.496	0.063	0.738
Age	0.212	0.236	0.113	0.544
BMI	0.206	0.250	–0.098	0.599
Comorbidities	0.301	0.089	0.159	0.391
White blood cells	0.515	0.002	0.646	0.000
Ultrasound findings	0.712	0.000	0.736	0.000
Operative time	0.700	0.000	0.652	0.000
Intraoperative complications	0.647	0.000	0.297	0.105
Concurrent pathology	–0.022	0.902	0.083	0.659

higher in the open group (two patients, 6.5%) versus none of the laparoscopic group patients. The meticulous irrigation of the peritoneal cavity can be done laparoscopically more efficiently than irrigation through limited access wound in open surgeries. Authors always emphasize changing the operating table position during irrigation and suction, using a large amount of saline to decrease the bacterial load and the risk of abscesses, and putting a pelvic drain to discard any residual saline wash. Postoperative ileus was more common in group II (3 cases, two of them associated with residual abscess). Early mobilization and bowel handling during the laparoscopic procedure reduce the incidence of adhesions and ileus in the postoperative period.

Despite the limitations of this study, such as the short study period and small population number, it gives a good indicator for the safety, superiority, and efficacy of laparoscopic over open appendectomy. Laparoscopic appendectomy has a significant benefit in patients who have suspicion in diagnosis. Patients' clinical and pathological characteristics, surgical experience, and equipment availability are critical factors in choosing the best approach for appendectomy. However, multi-center comparative studies with a larger population and more extended study periods are needed to definitively demonstrate the superiority of laparoscopic appendectomy.

Conclusion

Laparoscopic appendectomy had superior clinical outcomes than an open appendectomy in morbidly obese patients. In addition to minimal invasiveness and better cosmetic results, it has a great advantage as a diagnostic and therapeutic tool in morbidly obese patients with suspected appendicitis. It is also a safe and feasible approach with a low rate of complications with a well-trained expert surgeon.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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