Laparoscopic versus open appendectomy in the management of chronic appendicitis

Moamen S. Abdelgawaad, Mahmoud H. Elnabi Abd Elrazik, Mena H. Badee, Ragai Sobhy

General Surgery Department, Faculty of Medicine, Assiut University, Assiut, Egypt

Correspondence to Moamen S. Abdelgawaad, BSC, MSC, MD, Department of Surgery, Colorectal Division, Faculty of Medicine, Assiut University, El-Gamaa Street, Assiut 71515, Egypt. Tel: +20 101 752 0093; fax: +20882333327;
e-mail: moamen.shalkamy@aun.edu.eg

Received: 22 July 2023
Revised: 4 August 2023
Accepted: 8 August 2023
Published: 7 December 2023

The Egyptian Journal of Surgery 2023, 42:840–847

Background
The term 'chronic appendicitis' (CA) is still clearly undefined. However, once established, it necessitates appendectomy, which could be performed via open or laparoscopic approaches. Comparisons between the two approaches have been made in acute appendicitis cases, with no previous trials including CA patients. That is why we conducted this study to compare these two approaches in the management of CA patients.
Methodology
50 CA were included in our prospective trial, and they were randomly assigned into two groups; the OA group (25 open appendectomy patients) and the LA group (25 laparoscopic appendectomy cases).
Results
The statistical analysis revealed no significant differences between the two groups regarding most preoperative characteristics. The laparoscopic approach was associated with significant prolongation in operative time that had an average of 1 h in the LA group, while it ranged between 0.5 and 1 h in the OA group ($P = 0.005$). Nonetheless, laparoscopy led to a significantly better postoperative recovery profile, manifested in the shorter hospitalization period (1 vs. 2 days in the open approach) and less postoperative pain (all patients with mild pain compared with moderate pain in the open group). Only 2 (8%) casesexperienced temporary vomiting in the OA group.
Conclusion
Laparoscopy is superior to the open approach in the management of chronic appendicitis patients. It is associated with a better analgesic profile, a shorter hospitalization period, and a better chance of detecting other concomitant intraabdominal pathologies. However, the increased operative time should be considered.

Keywords:
chronic appendicitis, laparoscopy, open approach

Egyptian J Surgery 42:840–847

1110-1121

Introduction

Appendectomy for acute appendicitis is commonly performed in multiple surgical and emergency settings around the world. It is the standard management for patients with acute appendicitis [1,2]. Although the etiology and pathogenesis of acute appendicitis have been sufficiently delineated [3,4], the term 'chronic appendicitis' (CA) has not been clearly defined yet [5].

Compared with acute appendicitis, it is uncommon to encounter a patient with CA. CA patients represent 1–1.5% of all appendicitis patients [5,6], and it occurs secondary to partial or intermittent obstruction of the appendiceal lumen [7,8]. CA was traditionally defined as right lower quadrant pain of more than 2 days associated with fibrosis or long-standing appendiceal inflammation [9]. Others defined it as continuous right lower quadrant pain of three-week duration or more [10]. More recent research preferred to rely only on histopathological findings rather than clinical judgment [5].

Although CA is not a surgical emergency, it should be well diagnosed and managed to avoid its potential complications, including perforation, secondary peritonitis, intraabdominal abscess, or female infertility [8,11]. It is treated with appendectomy, like acute appendicitis [11], which could be performed via open or laparoscopic approaches [12,13].

Multiple trials have highlighted the superiority of the laparoscopic approach over the open one, and that

superiority was manifested in less invasiveness, less postoperative pain, shorter hospitalization, and better cosmetic outcomes [14–16]. Nonetheless, other studies showed marginal or no significant perioperative benefits of laparoscopy over the open approach in appendicitis cases, in addition to the high financial cost [17].

The current study is rich with comparative studies and meta-analyses comparing the open and laparoscopic approaches in the management of acute appendicitis [18–21]. However, studies comparing the same two approaches in patients with CA are lacking. That was a good motivation for us to perform the current study, which aimed to compare the open and laparoscopic approaches in the management of patients with CA.

Patients and methods

The current randomized prospective trial was conducted at Assiut University General Surgery Department over a one-year duration, from March 2022 to February 2023. We designed that study for adult patients diagnosed with CA who were fit for laparoscopy and general anesthesia. The diagnosis of CA was suspected when there was a history of right lower quadrant pain of three weeks or more, the presence of right lower abdominal tenderness on physical examination, and the radiological diagnosis of CA based on computed tomography (CT) or barium studies [22,23]. The pathology was confirmed postoperatively after examining the excised surgical specimen [5]. We excluded children, pregnant ladies, patients with acute or complicated appendicitis, and patients with severe uncontrolled medical comorbidities hindering general anesthesia or laparoscopy.

We only started patient enrollment and data collected after we had obtained ethical approval for our study protocol from the local ethical scientific committee of our medical school. We calculated our sample size using the G*power software (version 3.1.9.2 for Windows) and, depending on the *t*-test to detect the difference between the two groups using the following parameters; Alpha = 0.05, Power = 0.80, Effect size = 0.8, and Allocation ratio = 1. We required 50 patients to be included to achieve the previous requirements.

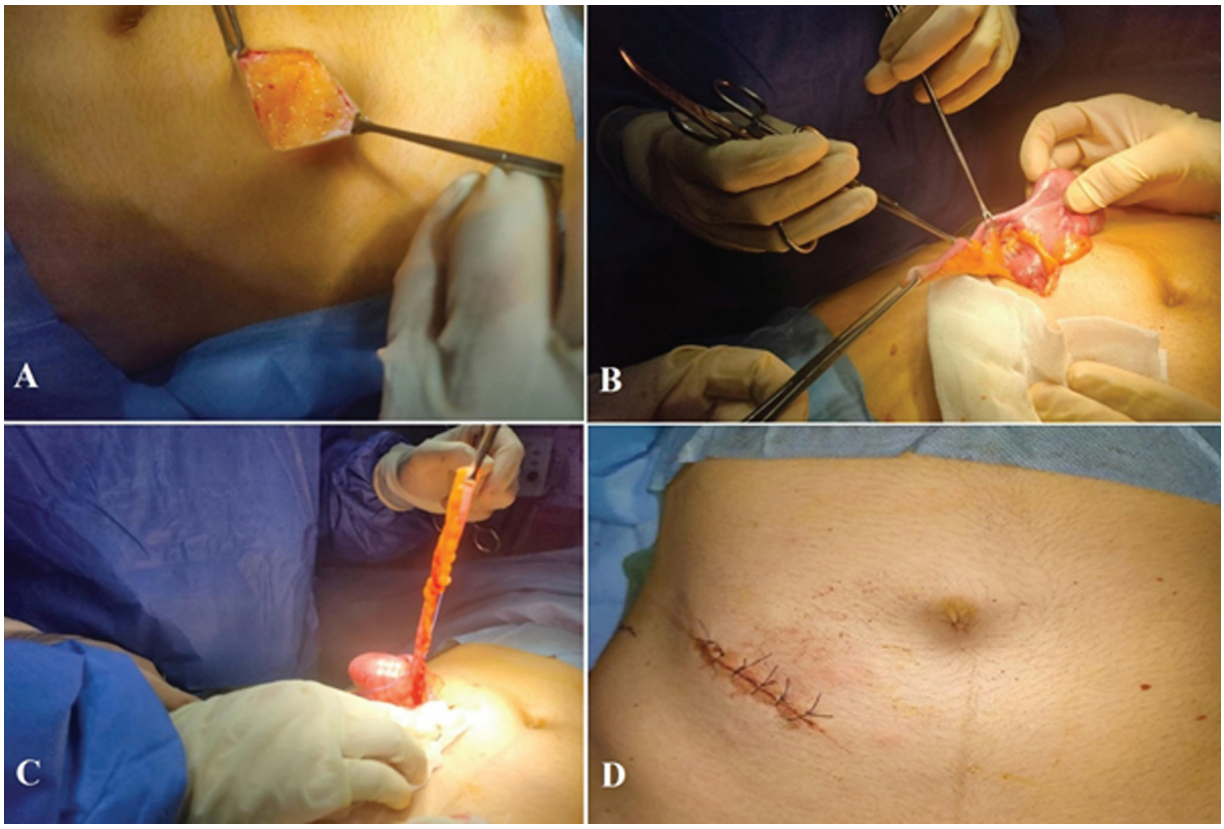
Preoperative assessment included history taking (focusing on the duration, pattern, and site of pain), clinical examination (focusing on abdominal palpation), and routine preoperative investigations. The radiological assessment included a pelviabdominal ultrasound, CT, and/or barium enema study. The patients were informed about the aim of the study, the benefits of the surgical procedure, the advantages, and possible complications of each approach. Then, they were admitted to the surgical ward, where they were randomly assigned into two groups; the OA group (25 cases who underwent the open approach) and the LA group (25 cases performed via laparoscopy). We performed the randomization using the 'sealed envelope technique'.

A broad-spectrum antibiotic was commenced for all patients at the time of skin incision (IV ceftriaxone 1 gm plus IV metronidazole 500 mg). In the OA group, the choice of anesthesia (general or spinal) was dependent on the anaesthesiologist's preference. The procedure was performed when the patient was in a supine position. The abdominal cavity was accessed through the Grid Iron incision. After incising the peritoneum, the appendix was palpated and delivered out of the abdomen. Ligation and division of the mesoappendix were done, followed by ligation of the appendiceal base by absorbable sutures. The appendix was then divided distal to the ligature, and the stump was buried via a purse string suture. After proper wash and hemostasis, the abdominal cavity was closed in layers using nonabsorbable sutures (Fig. 1).

In the LA group, all patients were performed under general anesthesia. The procedure was performed using the three-port approach (one periumbilical port for the camera, two working ports at right and left midclavicular lines just below the umbilical level) (Fig. 2). After abdominal exploration for any other concomitant pathology, the appendix was grasped, followed by coagulation and division of the mesoappendix and appendicular artery. The appendiceal base was secured by a metallic clip or a transfixing suture. The appendix was retrieved in a retrieval bag, followed by abdominal desufflation and closure of the ports. In both study groups, the excised specimen was sent to the histopathology laboratory to confirm the diagnosis.

Most patients were allowed to start oral intake within 12 h after the procedure, as long as there were audible intestinal sounds with sound abdominal examination. Postoperative pain was controlled by IV paracetamol (1 gm) in addition to IV ketorolac (30 mg) every 8 hours. IV morphine was commenced for any breakthrough pain. The pain was assessed via the Visual analog scale (VAS) [24], which was recorded every four hours during the hospital admission, and the mean of one-

Figure 1



Open appendectomy. (A) The skin incision. (B) Ligation of mesoappendix. (C) Ligation of the appendiceal base. (D) After skin closure.

day readings was calculated. Postoperative pain was classified as mild (visual analog scale 1–3), moderate (4–6), or severe (7 or more) [25]. Most patients were discharged from hospital on the first or second postoperative day. They were asked to return after 2-3 weeks for stitch removal. Any postoperative complications, including the need for reoperation, were recorded and managed.

The primary outcome of our trial was the duration of the procedure, while secondary objectives included intraoperative complications, postoperative pain, the duration of hospitalization, and postoperative complications.

Statistical analysis

The collected data were analyzed by the SPSS software for MacOS (version 26). We expressed categorical variables as numbers and percentages, while numerical data were presented as medians and interquartile ranges (IQR). These two data sets were compared between the two groups using the $\chi^2$and Mann-Whitney tests, respectively, considering that any yielded P value less than 0.05 was a significant finding.

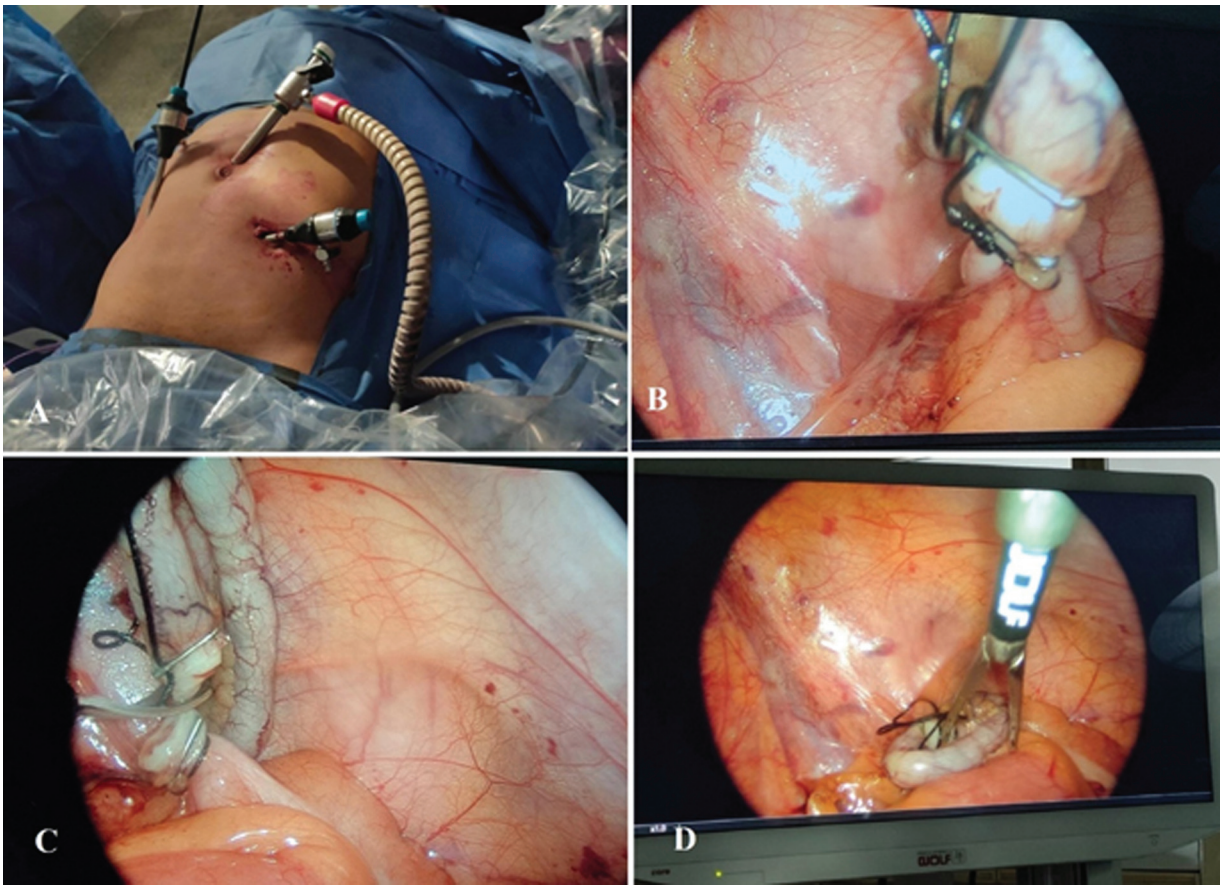
Results

Analysis of the patient's demographic characteristics revealed no significant difference between the OA and LA groups ($P > 0.05$) (Table 1), apart from body mass index (BMI), which showed a significant decline in the LA group (24 vs. 25 kg/m^2 in the OA group – $P = 0.005$). Despite the statistical significance, the difference in BMI between the two groups was clinically irrelevant.

The age of our patients had a median value of 21 years (IQR, 19–28.5) in the OA group, compared with 29 years in the LA group. Most participants were women, who formed 60% and 84% of cases in the previous two groups, respectively. No medical comorbidities were reported by the patients in the OA group. Nonetheless, in the LA Group, three (12%) patients had hypertension, while one (4%) patient had rheumatic heart disease.

Regarding radiological investigations, minimal intraabdominal free fluid was detected in only two patients in the LA group. Additionally, appendicular size had median values of 8 and 7 cm^3 in the OA and

Figure 2



Laparoscopic appendectomy. (A) Port design. (B) Clipping of the appendiceal base. (C) Division of the appendiceal base. (D) Delivery of the appendix.

Table 1 Baseline characteristics of the study groups

	OA group (*n*=25)	LA group (*n*=25)	*P* value
Age (years)	21 (19–28.5)	29 (20–34)	0.173
BMI	25 (25–26)	24 (23.5–25.5)	0.005
Sex			
Male	10 (10%)	4 (16%)	0.114
Female	15 (60%)	21 (84%)	
Medical disease			
Hypertension	0	3 (12%)	0.053
Rheumatic heart disease	0	1 (4%)	

LA groups, respectively, with a significant decline in the latter ($P=0.047$) (Table 2).

Preoperative laboratory investigations are shown in Table 3. These parameters expressed statistically comparable values between the two groups, except for the leucocytic and platelet counts that showed a significant rise in the OA group ($P=0.003$ and <0.001), respectively. These statistical differences were clinically unimportant, as most values were within the normal values (Table 3).

The majority of open procedures were performed under spinal anesthesia (92%), while all patients in the LA group were performed under general anesthesia ($P<0.001$). Concomitant intraoperative pathologies included right ovarian cyst (8%), nonrotation of the intestine (8%), and retroperitoneal lipoma (8%). All of these cases were detected in the LA group.

No significant blood loss or intraoperative complications were encountered with the two approaches. However, the laparoscopic approach was

Table 2 Radiological investigation findings in the study groups

	OA group (*n*=25)	LA group (*n*=25)	*P* value
Intraabdominal free fluid			
Minimal amount	0	2 (8%)	0.49
No free fluid	25 (100%)	23 (92%)	
Appendicular size (cm)	8 (7–9)	7 (6.75–7.25)	0.047

associated with a significant prolongation in the operative time, as all cases took 1 h in the laparoscopic group, while some cases were done within half an hour in the open group ($P=0.005$) (Table 4).

All laparoscopic patients were discharged within the first postoperative day, but the duration was extended for 2 days in the open group, making laparoscopy more advantageous than the open approach regarding the duration of hospitalization ($P<0.001$). Moreover, the laparoscopic approach was associated with a significant improvement in postoperative pain, as all patients reported mild pain, compared with the open approach, which was associated with moderate pain ($P<0.001$).

No patients developed postoperative hemorrhage, surgical site infection, or incisional hernia, and no patients required reoperation. Two patients experienced temporary vomiting in the open group (8%), and it was successfully managed by antiemetic medications (Table 5).

Discussion

Numerous studies have compared LA and the OA in the management of patients with acute appendicitis Horvath and colleagues, Dai and Shuai [26–28]. Nonetheless, little has been mentioned regarding the comparison between the same approaches in CA patients. That is why our study was conducted, and that poses an advantage in favor of our trial.

On looking at our preoperative patient characteristics, the reader could notice no significant statistical difference between the two groups regarding most variables. Even in variables with statistical significance, the differences were clinically unimportant. That denotes our proper randomization process. Moreover, that should decrease the risk of bias which might skew our findings in favor of one approach over the other one.

Our findings showed that the laparoscopic approach had a significantly longer operative time compared with the open one ($P=0.005$). Other studies confirmed our findings. Biondi and his associates reported that the same parameter had a mean value

Table 3 Laboratory investigations in the two study groups

	OA group (*n*=25)	LA group (*n*=25)	*P* value
Haemoglobin (g/dl)	12 (12–13)	12.5 (12–13)	0.703
WBCs (x103cells/μl)	10 (8–10)	8 (7–9)	0.003
Platelets (x103cells/μl)	350 (300–370)	280 (250–346)	<0.001
Prothrombin concentration (%)	90 (85–90)	90 (80–90)	0.554
INR	1 (1–1)	1 (1–1)	0.153

Table 4 Operative data in the study groups

	OA group (*n*=25)	LA group (*n*=25)	*P* value
Type of anesthesia			
General	2 (8%)	25 (100%)	<0.001
Spinal	23 (92%)	0	
Other findings			
Right ovarian cyst	0	2 (8%)	0.028
Intestinal nonrotation	0	2 (8%)	
Retroperitoneal lipoma	0	2 (8%)	
Blood loss			
Yes	0	0	-
No	25 (100%)	25 (100%)	
Intraoperative complications			
Yes	0	0	—
No	25 (100%)	25 (100%)	
Operative time (hr)	1 (0.5–1)	1 (1–1)	0.005

Table 5 Postoperative data of the study groups

	OA group (*n*=25)	LA group (*n*=25)	*P* value
Hospitalization period (day)	2 (2–2)	1 (1–1)	<0.001
Postoperative pain			
Mild	0	25 (100%)	<0.001
Moderate	25 (100%)	0	
Postoperative bleeding	0	0	—
Surgical site infection	0	0	—
Vomiting	2 (8%)	0	0.49
Incisional hernia	0	0	—
Reoperation	0	0	-

of 54.9±14.7 min when laparoscopy was used. However, the operative time significantly decreased to 31.36±11.43 min with the open approach (P <0.001) Biondi and colleagues [17]. In addition, Merhoff and his colleagues reported that the same parameter had average durations of 80 and 50 min in the laparoscopic and open groups, respectively, reflecting the more operative time spent on laparoscopy Merhoff and colleagues [29].

Laparoscopy is a relatively newer modality than the open approach, which used to be the standard and traditional approach for appendectomy in our center. Therefore, it is reasonable to spend more time with the newer approach compared with the older one.

Contrarily, Kehagias and colleagues [30] reported that both approaches had comparable operative times (P= 0.31), which had mean values of 47±19.7 and 44.3±24 min in the open and laparoscopic groups, respectively. One could expect some differences among studies according to the laparoscopic and surgical expertise, intraoperative difficulties, and intraoperative complications.

In our study, we were able to diagnose other pathologies in association with CA in the LA group. That highlights the advantage of laparoscopy in providing a complete visual assessment of the abdominal cavity Gaitan and colleagues, Kumar and colleagues [31,32] rather than the small Grid Iron incision, which is of nonexploratory nature.

Our findings showed a significant decrease in the intensity of postoperative pain in association with the laparoscopic approach (P <0.001). That could be secondary to the smaller incisions performed in laparoscopy compared with the open approach, and that coincides with multiple studies that confirmed the association between laparoscopy and better postoperative analgesic profile compared with the open approach Ortega and colleagues, Frazee and colleagues [33–35]. That would have a beneficial impact on postoperative recovery, which will manifest in early mobilization, less analgesic consumption, shorter hospitalization periods, and better patient satisfaction.

Our findings showed the incidence of vomiting in only 2 (8%) cases after the open approach versus no cases in the laparoscopic group. Despite the absence of statistical difference, the incidence of vomiting in the open group could be secondary to pain or increased opioid consumption Gan [36] due to the moderate pain in the open group.

In the current trial, the duration of hospitalization showed significant shortening in association with laparoscopy (1 versus 2 days in the open approach – P <0.001). That could be secondary to less postoperative pain, earlier mobilization, and earlier oral intake in the laparoscopic than in the open groups.

Hovarth and colleagues [26] reported similar findings, as the median hospitalization period was three days in the laparoscopic group compared with 4 days in the open one (P <0.001). Furthermore, Biondi and colleagues [17] reported that the same parameters had mean values of 1.4±0.6 and 2.7±2.5 days in the laparoscopic and open groups, respectively (P= 0.015). Although the previous two studies agreed with our findings regarding the superiority of laparoscopy, they reported hospitalization periods more or less different from ours. That could be explained by different patient and disease criteria, treatment protocols, and incidence of postoperative complications among surgical centers.

No wound infection occurred in our study, and that is also in agreement with a 2020 meta-analysis, which reported that the incidence of that complication ranges between 0 and 37.4% after appendectomy Danwang and colleagues [37]. We did not encounter any

mortality in our study, and that is in accordance with Katkhouda and colleagues [38] who reported the occurrence of no mortality in their study following appendectomy.

Although our study handled a unique surgical point of view that was rarely discussed in the literature, it has some drawbacks. First of all, we collected a relatively small sample of patients from a single surgical institution. Also, the financial cost of each approach should have been estimated. That is why more studies, including more patients from different surgical institutions, should be conducted soon.

Conclusion

According to the preceding findings, LA is superior to the OA in the management of CA patients. It is associated with a better analgesic profile, a shorter hospitalization period, and a better chance of detecting other concomitant intraabdominal pathologies. Nonetheless, the increased operative time should be considered.

Acknowledgements

Financial support: The present study did not receive any financial support

No potential conflict of interest was reported by the authors.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

References

1 Cohen-Arazi O, Dabour K, Bala M, Haran A, Almogy G. Management, treatment and outcomes of acute appendicitis in an elderly population: a single-center experience. Eur J Trauma Emerg Surg 2017; 43:723–727.9

2 Akmese OF, Dogan G, Kor H, Erbay H, Demir E. The use of machine learning approaches for the diagnosis of acute appendicitis. Emerg Med Int 2020; 2020:7306435.

3 Moris D, Paulson EK, Pappas TN. Diagnosis and management of acute appendicitis in adults: a review. JAMA 2021; 326:2299–2311.

4 Huerta S. Diagnosis and management of acute appendicitis. JAMA 2022; 327:1183–1184.

5 Kanat BH, Solmaz ÖA, Bozdağ P, Doğan S, Kutluer N, Kurt F, *et al.* Chronic appendicitis: the process from pre-diagnosis to pathology. Eur Rev Med Pharmacol Sci 2021; 25:7898–7902.

6 Hawes AS, Whalen GF. Recurrent and chronic appendicitis: the other inflammatory conditions of the appendix. Am Surg 1994; 60:217–219.

7 Vanwinter JT, Beyer DA. Chronic appendicitis diagnosed preoperatively as an ovarian dermoid. J Pediatr Adolesc Gynecol 2004; 17:403–406.

8 Shah SS, Gaffney RR, Dykes TM, Goldstein JP. Chronic appendicitis: an often forgotten cause of recurrent abdominal pain. Am J Med 2013; 126: e7–e8.

9 Kim D, Butterworth SA, Goldman RD. Chronic appendicitis in children. Can Fam Physician 2016; 62:e304–e305.

10 Mengesha MD, Teklu GG. A case report on recurrent appendicitis: An often forgotten and atypical cause of recurrent abdominal pain. Ann Med Surg 2018; 28:16–19.

11 Lee CK, Pelenyi SS, Fleites O, Velez V, Alaimo KL, Ramcharan DN, *et al.* Chronic Appendicitis, the lesser-known form of appendiceal inflammation: a case report. Cureus 2021; 13:e19718.

12 Lee SH, Lee JY, Choi YY, Lee JG. Laparoscopic appendectomy versus open appendectomy for suspected appendicitis during pregnancy: a systematic review and updated meta-analysis. BMC Surg 2019; 19:41.

13 Wang D, Dong T, Shao Y, Gu T, Xu Y, Jiang Y. Laparoscopy versus open appendectomy for elderly patients, a meta-analysis and systematic review. BMC Surg 2019; 19:54.

14 Talha A, El-Haddad H, Ghazal AE, Shehata G. Laparoscopic versus open appendectomy for perforated appendicitis in adults: randomized clinical trial. Surg Endosc 2020; 34:907–914.

15 Jaschinski T, Mosch C, Eikermann M, Neugebauer EA. Laparoscopic versus open appendectomy in patients with suspected appendicitis: a systematic review of meta-analyses of randomised controlled trials. BMC Gastroenterol 2015; 15:48.

16 Ali R, Anwar M, Akhtar J. Laparoscopic versus open appendectomy in children: a randomized controlled trial from a developing country. J Pediatr Surg 2018; 53:247–249.

17 Biondi A, Di Stefano C, Ferrara F, Bellia A, Vacante M, Piazza L. Laparoscopic versus open appendectomy: a retrospective cohort study assessing outcomes and cost-effectiveness. World J Emerg Surg 2016; 11:44.

18 Swank HA, Eshuis EJ, van Berge Henegouwen MI, Bemelman WA. Short- and long-term results of open versus laparoscopic appendectomy. World J Surg 2011; 35:1221–1226. discussion 7-8.

19 Poprom N, Wilasrusmee C, Attia J, McEvoy M, Thakkinstian A, Rattanasiri S. Comparison of postoperative complications between open and laparoscopic appendectomy: An umbrella review of systematic reviews and meta-analyses. J Trauma Acute Care Surg 2020; 89:813–820.

20 Saia M, Buja A, Baldovin T, Callegaro G, Sandonà P, Mantoan D, *et al.* Trend, variability, and outcome of open vs. laparoscopic appendectomy based on a large administrative database. Surg Endosc 2012; 26:2353–2359.

21 Nazir A, Farooqi SA, Chaudhary NA, Bhatti HW, Waqar M, Sadiq A. Comparison of Open Appendectomy and Laparoscopic Appendectomy in Perforated Appendicitis. Cureus 2019; 11:e5105.

22 Rao PM, Rhea JT, Novelline RA, McCabe CJ. The computed tomography appearance of recurrent and chronic appendicitis. Am J Emerg Med 1998; 16:26–33.

23 Dai L, Jin X, Xie H, He T, Cheng H, Zhu Y, *et al.* The effect of antibiotic prophylaxis on the incidence of surgical site infection after laparoscopic appendectomy for chronic appendicitis. Heliyon 2023; 9:e15578.

24 Heller GZ, Manuguerra M, Chow R. How to analyze the Visual Analogue Scale: Myths, truths and clinical relevance. Scand J Pain 2016; 13:67–75.

25 Jones KR, Vojir CP, Hutt E, Fink R. Determining mild, moderate, and severe pain equivalency across pain-intensity tools in nursing home residents. J Rehabil Res Dev 2007; 44:305–314.

26 Horvath P, Lange J, Bachmann R, Struller F, Königsrainer A, Zdichavsky M. Comparison of clinical outcome of laparoscopic versus open appendectomy for complicated appendicitis. Surg Endosc 2017; 31:199–205.

27 Athanasiou C, Lockwood S, Markides GA. Systematic Review and Meta-Analysis of Laparoscopic Versus Open Appendicectomy in Adults with Complicated Appendicitis: an Update of the Literature. World J Surg 2017; 41:3083–3099.

28 Dai L, Shuai J. Laparoscopic versus open appendectomy in adults and children: A meta-analysis of randomized controlled trials. United European Gastroenterol J 2017; 5:542–553.

29 Merhoff AM, Merhoff GC, Franklin ME. Laparoscopic versus open appendectomy. Am J Surg 2000; 179:375–378.

30 Kehagias I, Karamanakos SN, Panagiotopoulos S, Panagopoulos K, Kalfarentzos F. Laparoscopic versus open appendectomy: which way to go?. World J Gastroenterol 2008; 14:4909–4914.

31 Gaitán HG, Reveiz L, Farquhar C, Elias VM. Laparoscopy for the management of acute lower abdominal pain in women of childbearing age. Cochrane Database Syst Rev 2014; 5:Cd007683.

32 Kumar R, Saxena N, Chaudhary P, Ahirwar N, Gautam S, Munjewar C, *et al.* Role of diagnostic laparoscopy in patients with non-specific abdominal pain and its correlation with clinical and radiographic findings. Hellenic J Surg 2016; 88:268–275.

33 Ortega AE, Hunter JG, Peters JH, Swanstrom LL, Schirmer B. A prospective, randomized comparison of laparoscopic appendectomy with open appendectomy. Laparoscopic Appendectomy Study Group. Am J Surg 1995; 169:208–212.

34 Moore DE, Speroff T, Grogan E, Poulose B, Holzman MD. Cost perspectives of laparoscopic and open appendectomy. Surg Endosc 2005; 19:374–378.

35 Frazee RC, Roberts JW, Symmonds RE, Snyder SK, Hendricks JC, Smith RW, *et al.* A prospective randomized trial comparing open versus laparoscopic appendectomy. Ann Surg 1994; 219:725–728.

36 Gan TJ. Poorly controlled postoperative pain: prevalence, consequences, and prevention. J Pain Res 2017; 10:2287–2298.

37 Danwang C, Bigna JJ, Tochie JN, Mbonda A, Mbanga CM, Nzalie RNT, *et al.* Global incidence of surgical site infection after appendectomy: a systematic review and meta-analysis. BMJ Open 2020; 10:e034266.

38 Katkhouda N, Mason RJ, Towfigh S, Gevorgyan A, Essani R. Laparoscopic versus open appendectomy: a prospective randomized double-blind study. Ann Surg 2005; 242:439–448.