**Original Article**

**Patterns and Predictors of Surgical Approaches among Patients Diagnosed with Appendicitis**

Khalid Ahmed Aljasser 1, Ayman Muheisen Salem Alhouli 2, Abdulaziz Ayad Alqudaimi 3, Rahaf Ahmed Alamer 4, Khalid Saleh Aloufi 5, Najd Abdulrahman Al-Mutairi 6, Zahra Mohammed Alyousef 7, Abdullah Mohammed Alrofydi 8, Shayma Saleh Al-Rubaki 9, Abdullah Khalid Alghutayghit 10, Khulud Ali Bakri 8, Zaid Abdulrahim Majeed 11, Abdullah Hamad Alkharraz 12, Osamah Salem Alsawat 13, Lama Ghassan Abdullah 9

1. Imam University, Riyadh, Saudi Arabia;
2. Senior Registrar of General Surgery, Al Qurayyat General Hospital, Al Qurayyat, Saudi Arabia;
3. Dar Al Uloom University, Riyadh, Saudi Arabia;
4. Medical Intern, King Khalid University Medical College, Abha, Saudi Arabia;
5. Medical intern, Taibah University Faculty of Medicine, Medina , Saudi Arabia;
6. Medical Intern, Imam Abdulrahman Bin Faisal University, Dammam, Saudi Arabia;
7. Physician, Alfaisal University College of Medicine, Dammam, Saudi Arabia;
8. Medical Intern, King Khalid University, Abha, Saudi Arabia;
9. Medical Intern, Batterjee Medical College, Jeddah, Saudi Arabia;
10. Medical Intern, Jouf university, Sakaka, Saudi Arabia;
11. Medical Student, Umm Al-Qura University, Makkah, Saudi Arabia;
12. Medical Intern, Alqassim University, Uniazah, Saudi Arabia;
13. Medical Intern, King Abdulaziz University Hospital, Jeddah, Saudi Arabia

**Correspondence to:**

Lama Ghassan Abdullah

Medical Intern, Batterjee Medical College, Jeddah, Saudi Arabia

Email: lama.abdullah94@hotmail.com

**Abstract**

**Background:** Appendicitis is one of the most frequently encountered surgical emergencies across hospitals worldwide. With increasing global prevalence and incidence, choosing the most appropriate surgical approach is vital for both pathological and patient outcomes. Choice of surgical appendectomy is currently limited to either laparoscopic or open. Enhanced recovery after surgery (ERAS) protocol is greatly implicated by surgical approach. This involves enhancing perioperative course as well as optimizing patient’s quality of life.

**Research significance:** The aim of this study was to evaluate the effectiveness and perioperative outcomes of laparoscopic and open approaches, respectively. As postoperative outcomes incur great costs to both the patient and the hospital; control of such outcomes is vital.

**Objectives:** To compare patients’ characteristics undergoing laparoscopic appendectomy versus converted to open surgeries.

**Methodology:** This retrospective cross-sectional study recruited 405 patients with the clinical diagnosis of acute/complicated appendicitis. Recruitment phase was around one year, with data collected and analyzed on excel sheets.

**Results:** In terms of reduced postoperative outcomes, laparoscopic appendectomy was found to be superior in less complicated cases of appendicitis. Open appendectomy was deemed to be the treatment of choice in patients with known surgical history. This was mainly due to adhesion formation and risk of disseminated infection.

**Conclusion:** Choice of surgical approach is highly dependent on patient’s past surgical history, overall wellbeing of the patient, and the pathological state of the appendix. However, use of laparoscopic appendectomy in uncomplicated appendicitis has received global consensus.

**Keywords:** laparoscopic appendectomy, open appendectomy, acute appendicitis, laparoscopic surgery, abdominal pain, comorbidities

**Introduction**

Appendicitis, defined as inflammation of the vermiform appendix [1], is currently the commonest and most frequently performed abdominal surgical emergency [2].Delay in diagnosis and timely management may lead to detrimental consequences as abscess formation, ileus, peritonitis, or even death [1]. Reported lifetime risk of appendicitis equates to approximately 7%–8% [3]. Appendicitis possesses a bimodal age distribution; it accounts for most acute abdomen cases in individuals aged between 10-20 years of age as well patients aged greater than 50. Incidence is noted to be greater in males (8.6%) when compared to (6.9%) in females [2]. On the contrary, appendectomy rates amongst female patient (23%) are two times higher than in male patients (12%) [2].

Despite the existence of multiple theories, the etiology of appendicitis remains uncertain. The principal theory constitutes luminal obstruction as the set point of the pathogenic process. This consequently leads to entrapment of mucosal secretions, an increase of intraluminal pressure, and ischemia of the appendiceal wall. Bacterial involvement causes further inflammation, eventually complicated appendicitis, and disseminated infection by means of infarction and perforation. Causes of luminal obstruction include lymphoid hyperplasia, fecaliths, foreign bodies, and malignancy [1,2].

Patients with acute appendicitis typically present with colicky periumbilical pain which later localizes to the right iliac fossa. Associated symptoms include malaise, nausea, vomiting, and anorexia. On examination, there is tenderness in the right iliac fossa with signs of peritoneal irritation. This indicates an increased likelihood of acute appendicitis. For prompt diagnosis of appendicitis, a holistic approach is mandatory. This includes a focused history, abdominal exam with special tests, as well the appropriate laboratory investigations. Laboratory tests are primarily performed to either dismiss other pathologies or support a current diagnosis. Computed tomography (CT) with intravenous contrast is considered the mainstay to pathologically confirm a diagnosis of acute appendicitis [2].

Appendicitis management entails both medical and surgical interventions. The choice of intervention depends on several factors as the patient’s general health and the inflammatory stage of the appendix [4]. Liaising with microbiology regarding antibiotic protocols is vital. Antibiotic regimen needs to be active against both aerobic and anaerobic bacteria to ensure complete resolution of symptoms. Antimicrobials are still indicated despite a possible foreseen appendectomy [5]. Preoperatively patients usually present with dehydration, fever, acidosis, and sepsis. As part of management continuum, intravenous fluids and antibiotics are frequently indicated [4].

Surgical management is currently limited to open and laparoscopic appendectomies. In an open approach, an incision is made in the right iliac fossa, commonly with a Rocky Davis rather than a McBurney incision [6]. In a laparoscopic approach, a small midline incision is made at the umbilicus where a trocar and a camera are inserted at the incision site. Then under direct visualization, two trocars are placed in the lower left midline of the abdomen and the right midline of the abdomen, respectively [6].

Since its debut by McBurney in 1894, open appendectomy (OA) has been the treatment of choice for acute appendicitis during that century. In 1983, Kurt Semm published the first description of laparoscopic appendectomy (LA). Laparoscopic surgery has grown in popularity and found application in practically every surgical specialty. This is attributed to the success of laparoscopic cholecystectomy, which has quickly become the gold-standard therapy for gallstone disease.

In randomized comparisons with OA, LA has been found to be a practical and safe alternative to the invasive open approach. LA improves diagnostic accuracy while also considerably resulting in fewer wound infections, decreased levels of postoperative analgesia, faster recovery, and a smoother return to regular activities [7]. However, due to reports of a greater incidence of intra-abdominal abscesses (IAAs), the choice of LA in complicated appendicitis remains debatable [8]. As a result, there is no consensus on whether laparoscopy should be conducted only in a certain cohort of patients as young females, obese patients, and employed patients. As opposed to routinely performing LA in all patients without a suspected IAA [9,10].

Differing morbidity rates and surgical site infections are observed for laparoscopic appendectomies and OAs. Postoperative infections are more commonly encountered in complicated appendicitis. Infectious complications have been shown to be less prevalent following laparoscopic surgery when compared to open surgery in various meta-analysis studies [11]. A German literature review of 25 studies was conducted by Maximilian Sohn et al (2017), primarily to evaluate the various types of approaches to appendectomy. It was found that the LA rate was reported to be 86% and LA was documented as “state of the art” in the treatment of acute appendicitis [12].

 A review article by Mohammed Miftah et al (2018) compared the efficacy, safety, and complications of LAs and OAs that were carried out in Saudi Arabia. The clinical endpoints included mean operative time, mean hospital stay, and prevalence of postoperative complications; that is, mainly wound infections and intra-abdominal infections (refer to table 1). No other literature review was found to compare patient characteristics undergoing LA versus those converted to open approach [13].Thereby the debate to convert to OA is based on various factors. There is limited data regarding the practice of the two procedures in Saudi Arabia. The study outlined below aimed to investigate the patterns and predictors of surgical interventions in patients diagnosed with appendicitis at the National Guard Hospital in Riyadh. Various endpoints were compared between LA and converted to open appendectomy (COA).

**Methods**

The institutional KAIMRC Data was collected from patient medical records. Recruitment criteria involved patients who had undergone an appendectomy during the last 18 months in KAMC in Riyadh, kingdom of Saudi Arabia.

This study included 437 total sample size, with the final sample size being 405 participants. Exclusion criteria included patient aged less than 16 years along with pregnant females.

**Study design and setting**

This study is an observational chart review and retrospective cross-sectional study of patients diagnosed with acute or perforated appendicitis who underwent LA at King Abdulaziz Medical City in Riyadh, Kingdom of Saudi Arabia from January 2018 until July 2019.

**Population and sample size**

From January 2018 until July 2019, 405 patients who were diagnosed with acute or perforated appendicitis with a documented LA met the inclusion and exclusion criteria. We included all patients who were 16 years or older, had a confirmed diagnosis of appendicitis, and underwent LA during the study period. Pregnant females and patients with missing data were excluded in effort to minimize collection bias.

**Data management and analysis plan**

All data were collated using Excel sheets. In addition, patients’ medical records were thoroughly reviewed to obtain patient demographics and clinical characteristics. All information was recorded on the data collection form to reduce bias. Demographics and clinical data were reported as frequencies or proportions for categorical data interpretation. Statistical analysis was done using the mean ± standard deviation or median (interquartile range) for continuous variables, as seen appropriate. Differences in patient demographics and clinical characteristics between the two groups (LA and COA) were evaluated with a Mann-Whitney U-test, Pearson’s Chi-squared test, or Fisher’s exact test, as deemed appropriate. The data were analyzed with univariable analysis (simple logistic regression) and multivariable analysis (multiple logistic regression). Statistical analysis was performed using IBM SPSS Statistics for Windows ver. 23.0. A p-value less than 0.05 was considered significant.

**Ethical Considerations**

The study was started only after obtaining permission and approval by the institutional review board (IRB) of King Abdulaziz Medical City in Riyadh, Kingdom of Saudi Arabia. Patients’ identities remained anonymous throughout the study to all evaluators.

**Discussion**

Acute appendicitis (AA) is one of the most common causes of operative abdominal emergencies [14,15,16,17]. Appendectomy has been the choice for treating AA for over a century. Approach to appendectomies is limited to either as open or laparoscopic. LA has become the treatment of choice for treating acute appendicitis due to its advantages over OA regarding shorter hospital stays, less postoperative pain, and fewer infectious complications [18,19,20].

Our study was based on 405 patients who had undergone appendectomies, with 395 undergoing a LA and 10 patients converted to an OA. Variables listed in Table 2, were tested for significance based on a 95% confidence interval level.

The mean age of study participants (38.60 ± 16.15) who were converted to OA was noted to be greater than the age of patients (28.63 ± 12.40) who had a LA. The patients who had a LA were significantly younger than OA patients with a p value < 0.03. Moreover, diabetic patients had a significant association between LA and conversion to OA (p = 0.0256). This finding was further confirmed by another study conducted by Suresh Kumar et al. It illustrated a significant association between the conversion rate to OA in diabetic patients [21].

Our study showed no statistical significance in terms of body mass index (BMI), smoking, sex distribution, other comorbidities (coronary artery disease, hypertension, dyslipidemia, and chronic obstructive pulmonary disease). Additionally, the American Society of Anesthesiologists (ASA) concluded no significant differences between the two groups (p = 0.5211). These aforementioned factors were ruled out as determinants for appendectomy treatment choices. On the contrary, a study by Nicola et al aiming to identify an association between converted OAs and LAs, attributed the presence of comorbidities as a predictor of conversion to open [22]. Variables examined included age, BMI, sex, comorbidities, Alvarado scores, costs, and time of hospitalization. Moreover, recent studies have shown significant advantages of LA with respect to shorter hospital stays, postoperative pain, and infectious complications [16, 21, 22,23].

In this study, patients who had a LA had a mean age of 28.63 ± 12.40 while patients who had an OA had a mean age of 38.60 ± 16.15. There was a male preponderance. Similar demographics were observed in another study [21]. The rate of OA was significantly higher in male patients than in females.

The total operative time in this study was significantly longer in patients who had an OA (140.67 ± 53.92 minutes) when compared to LA (81.80 ± 33.34 minutes). The contrary was observed in the referenced studies, showing that surgeons consumed more time during LAs than in OAs [16, 21, 22, 23]. This difference ascertained that length of laparoscopic operations is directly correlated with surgeons’ level of experience.

Our study indicated there was a significantly shorter hospital stay (1.90 ± 1.90 days) in the patients who had a LA compared with that in patients who had an OA (4.60 ± 2.99, P 0.0332). This finding was deemed to be consistent across all the other studies evaluated and further supported by the Cochrane Collaboration large scale meta-analysis [24].

Despite lacking a significant difference in the distribution of LAs or OAs [22], patients with complicated appendicitis were most likely to have longer hospital stays [16]. In our study, iatrogenic causes of complicated appendicitis (perforation, gangrene, abscess, or peritonitis) were more frequently documented with LAs. Earlier studies regarding surgical approaches in complicated appendicitis, have documented LA as an absolute contraindication [24].Though with increasing scientific advancements and understanding of the technique, LA is now deemed safe for complicated appendicitis [25].

The Alvarado score, as listed in table 3, enables risk stratification in patients presenting with suspected acute appendicitis. It aids in affirming the diagnosis as well as linking the probability of appendicitis to recommendations regarding discharge, observation levels, or surgical intervention [26,27,28,29]. In this study, the Alvarado score was used to correlate admission severity risk to incidence of conducted LA versus COA. Ninety-eight patients had a low-risk score (1–4), of which three were converted to OA (3.01%). There were 137 patients with an intermediate risk score (5–6) with only one converted to OA (0.7%). There were 160 high risk patients (7–10) with six converted to OA (3.75%). In our study, Alvarado's score showed no significant predictive value between LA and COA.

Regarding the index outpatients’ department visit, there were 8.75 ± 3.40 in the laparoscopic group and 8.00 ± 3.40 in the converted to OA group, which was not significantly different. Three hundred fifty-eight patients were found on scheduled outpatient appointments, resulting in 349 LA with nine patients converted to OA. For those who presented to the ED with appendicitis, only 39 were converted to OA. Other presenting complaints the ED included surgical site discharge (four patients), fever (two patients), chills/rigors (one patient), and vomiting (one patient). All of which were managed with LA. This further supports the absence of a significant predictive value regarding these variables.

**Results**

Results obtained from this cross-sectional study are summarized in the tables below and thoroughly explained in the discussion section.

**Table 1** outlines reduced length of hospital stay and operative times in the laparoscopic group. Use of CT in both study groups was statistically comparable. More incidental and iatrogenic surgical findings were documented in the laparoscopic group.

**Table 1** Operative and postoperative clinical data

|  |  |  |  |
| --- | --- | --- | --- |
|  | Laparoscopic(n = 395) | Converted to open(n = 10) | P  |
|  |  |  |  |
| Operative time (min) | 81.80 ± 33.34 | 140.67 ± 53.92 | 0.0332 |
|  |  |  |
|  |  |  |  |
| Hospital stay (days) | 1.90 ± 1.90 | 4.60 ± 2.99 | 0.0332 |
|  |  |  |  |
| Discharged with Antibiotics |  |  |  |
| Discharged without Antibiotics |  |  |  |
|  |  |  |
| CT Scan |  |  |  |
| Underwent CT scan | 265 (67.09) | 9 (90.00) | 0.1776 |
| Didn't underwent CT scan | 130 (32.91) | 1 (10.00) |  |
|  |  |  |
| CT scan findings |  |  |  |
| No CT was done | 32 (10.88) | 0 | 0.0768 |
| Uncomplicated appendicitis | 199 (67.69) | 4 (44.44) |  |
| Complicated appendicitis | 27 (9.18) | 2 (22.22) |
| Perforated appendicitis | 36 (12.24) | 3 (33.33) |  |
|  |  |  |  |
| Surgical findings  |  |  |
| Appendicitis | 188 (48.08) | 2 (20) | 0.0527 |
| Acute suppurative appendicitis | 68 (17.39) | 3 (30) |  |
| Acute gangrenous appendicitis | 18 (4.60) | 0 |
| Acute necrotizing appendicitis  | 4 (1.02) | 0 |  |
| Lymphoid hyperplasia | 6 (1.53) | 0 |  |
| Mucinous lesions | 3 (0.77) | 1 (10) |
| Carcinoid tumor  | 1 (0.26) | 0 |  |
| Fibrous obliterations | 2 (0.51) | 0 |  |
| Appendicular diverticulus  | 1 (0.26) | 0 |  |
| Serotitis | 6 (1.53) | 1 (10) |  |
| Peritonitis | 8 (2.05) | 0 |  |
| enteritis  | 1 (0.26) | 0 |  |
| Acute appendicitis with abscess | 3 (0.77) | 0 |  |
| Perforated | 24 (6.14) | 3 (30) |  |
| Granulomatous | 2 (0.51) |  |  |
|  |  |  |  |
|  |  |  |  |

**Table 2** outlines dominant application of the laparoscopic approach in 97.5% of study participants. This patient cohort encompassed patients with higher risk factors to adverse surgical outcomes as smoking, coronary artery disease, hypertension, diabetes, and chronic obstructive pulmonary disease. BMI was almost similar amongst both groups of patients. Nonetheless, it was slightly higher in the COA group at 27.10 ± 6.74.

**Table 2** Demographic and preoperative clinical data.

|  |  |  |  |
| --- | --- | --- | --- |
|  | Laparoscopic(n = 395) | Converted to open(n = 10) | P  |
| Gender |  |  |  |
| Male | 214 (61.49) | 7 (87.50) | NS |
| Female | 134 (38.51) | 1 (12.50) |
|  |  |  |  |
| Mean age | 28.63 ± 12.40 | 38.60 ± 16.15 | 0.0332 |
|  |  |  |  |
| BMI | 26.19 ± 6.52 | 27.10 ± 6.74 | 0.6748 |
|  |  |  |  |
| Smoking |  |  |  |
| Smokers | 48 (12.21) | 2 (20.00) | 0.3581 |
| Non-smokers | 345 (87.79) | 8 (80.00) |
|  |  |  |  |
| Patients with Comorbidities |  |  |  |
| Patients with (CAD) | 6 (1.52) | 1 (10) | 0.1620 |
| Patients without (CAD) | 388 (98.48) | 9 (90) |
|  |  |  |  |
| Patients with (HTN) | 20 (5.06) | 1 (10) | 0.4164 |
| Patients without (HTN) | 375 (94.94) | 9 (90) |
|  |  |  |  |
| Patients with (DLP) | 7 (1.77) | 1 (10) | 0.1827 |
| Patients without (DLP) | 388 (98.23) | 9 (90) |
|  |  |  |  |
| Patients with (DM) | 25 (6.33) | 3 (30) | 0.0256 |
| Patients without (DM) | 370 (93.67) | 7 (30) |
|  |  |  |  |
| Patients with (COPD) | 18 (4.57) | 1 (10) | 0.3857 |
| Patients without (COPD) | 376 (95.43) | 9 (90) |
|  |  |  |  |
| American society of Anesthesiologists |  |  |  |
|  |  |  |  |
| ASA I E | 214 (54.18) | 4 (40.00) | 0.5211 |
| ASA II E | 169 (42.78) | 6 (60.00) |  |
| ASA III E | 9 (2.28) | 0 |  |
| ASA IV E | 3 (0.76) | 0 |  |
|  |  |  |  |

**Table 3** correlates patients’ route of admission, Alvarado score, and nature of presenting complaint to the surgical approach utilized.

**Table 3** Alvarado score presentation and follow-up clinical data

|  |  |  |  |
| --- | --- | --- | --- |
|  | Laparoscopic(n = 395) | Converted to open(n = 10) | P  |
|  |  |  |  |
| Alvarado Score |  |  | 0.2733 |
| Low risk (1–4) | 98 (24.81) | 3 (30) |
| Intermediate risk (5–6) | 137 (34.68) | 1 (10) |  |
| High risk (7–10) | 160 (40.51) | 6 (60) |  |
|  |  |  |  |
| 1st OPD visit | 8.75 ± 3.40 | 8.00 ± 3.40 | 0.3704 |
|  |  |  |  |
| 30 days ER visits | 18 (6.47) | 3 (50%) | 0.0061 |
|  |  |  |  |
| Cause of ER visit |  |  |
| No visit | 349 (88.35) | 9 (90) |  |
| Abdominal pain | 38 (9.62) | 1 (10) |  |
| Surgical site discharge | 4 (1.01) | 0 |  |
| Fever | 2 (0.51) | 0 |  |
| Chills | 1 (0.25) | 0 |
| Vomiting | 1 (0.25) | 0 |  |
|  |  |  |
|  |  |  |  |

**Conclusion**

After estimating the rate of conversion to open appendectomy in our study, old age, and/or being a diabetic patient were predictive factor/s that affected receiving a LA or converting to an OA.

The study included 405 participants, of which 395 (97.5%) underwent LA and the remaining 10 (2.5%) were COA. We have also concluded that the mean age among COA and diabetic patients to be considerably higher. Moreover, the total operative time along with the 30-day post-operative emergency department (ED) visits were noted to be significantly higher than those who have undergone laparoscopic appendectomies. Conversion to open appendectomy is hence directly related to increased post-operative morbidity. Thus, surgeons are highly encouraged to utilize the minimally invasive laparoscopic when deemed possible.

 **Conflict of interests:**

The authors declare that there is no conflict of interest regarding the publication of this article.

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**Ethics Approval:**

IRB Committee at King Abdullah International Medical Research Center (KAIMRC) approved the study - Memo Ref. No. IRBC/918/17.

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